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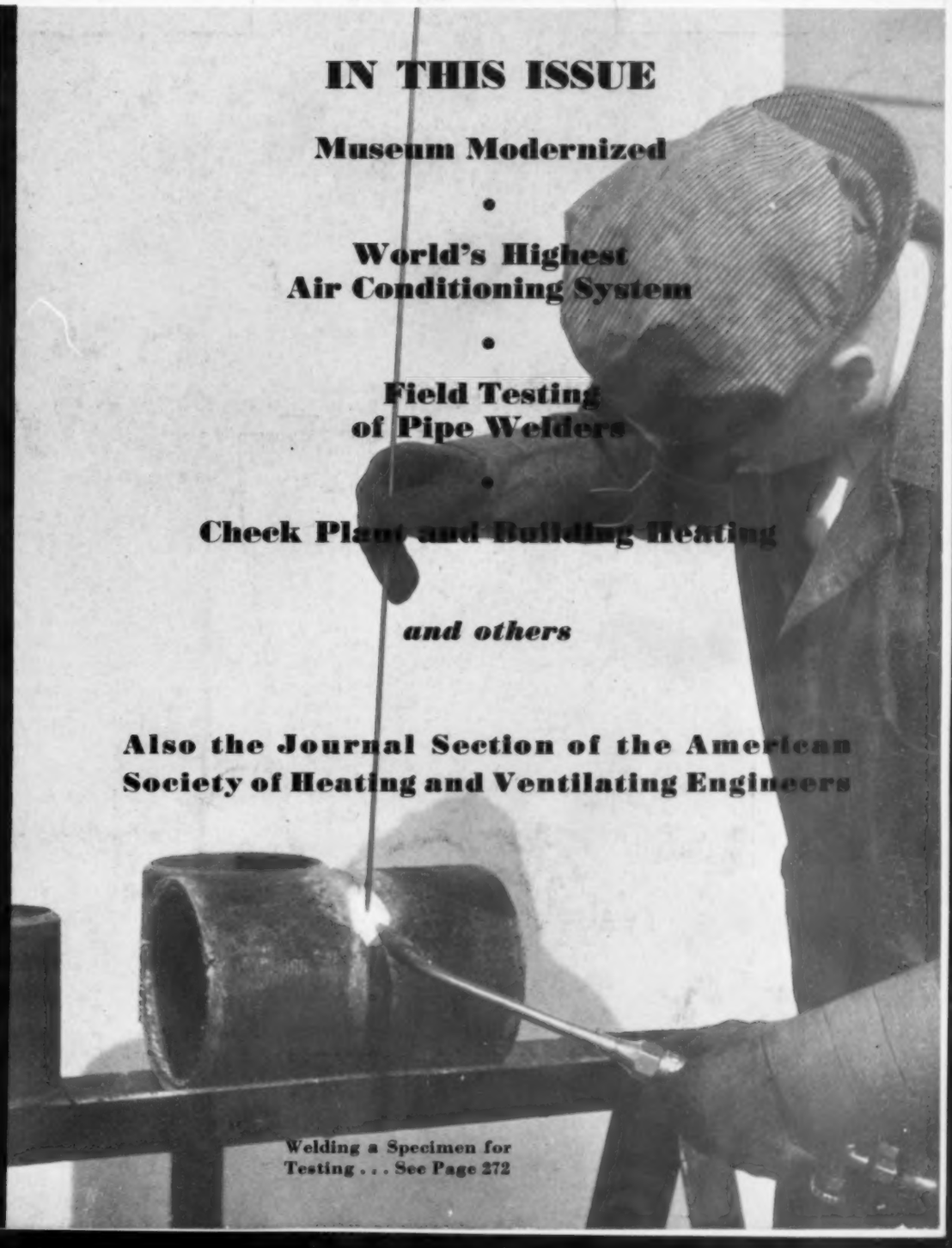

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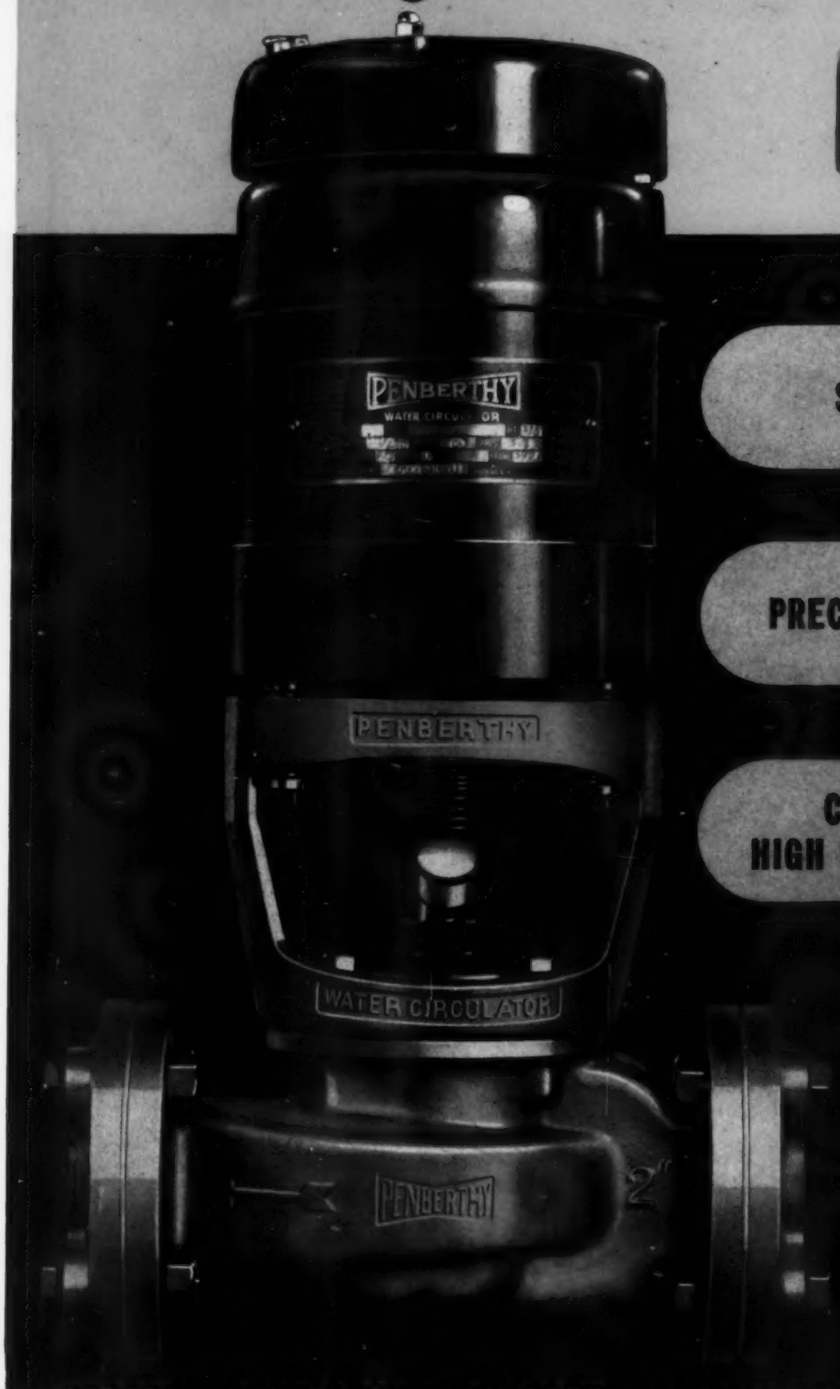

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THIS month — Remodeling of the Brooklyn Museum, built in 1901, is described by Arthur C. Babcock; this is an outstanding example of modernization of an old public building, proves that a thirty-year-old building of this type can be arranged and equipped to meet today's needs . . . The rebuilt structure has a modern heating system, a ventilation system so arranged as to be converted later into an air conditioning system for the protection of the exhibits . . . D. O. Ferguson's paper on field testing and instruction for pipe welders is a comprehensive explanation of a carefully thought out program based on the idea of aiding the welder to insure good pipe welding . . . "World's highest" air conditioning system serves the American Cyanamid Co. offices in the R. C. A. building, New York. The design—described by A. B. Wason in this issue—involved a number of problems because all equipment had to be located in the leased areas, the 57 to 61st floors of a 70 story building . . . Kalman Steiner continues his description of a bulk fuel oil storage plant this month, covering the design of the piping and the heating of the storage tanks, which is necessary so that pumping will be possible. Details of the steam coils installed in the tanks are included . . . T. Napier Adlam supplements his April article with additional suggestions for checking up plant and building heating *now* to assure better operation next winter . . . Many a plant has a department that must be closed off from other areas to protect the product; an aeronautical instrument test and repair room, for instance, must be absolutely clean and therefore sealed against dust and dirt. This means cooling, as otherwise temperatures would be too high for comfort. A. J. Rummel describes an air conditioning installation of this type in his article.

WHAT is the effect of using superheated steam in radiators? Prof. A. P. Kratz recently answered this question for a reader, and his answer is published this month for the benefit of others . . . What about standards for air conditioning? has been the question discussed pro and con at many a meeting, many a lunch table. The views of several engineers and contractors appear under that heading in a brief symposium on page 290 . . . Samuel R. Lewis tells what's wrong with a hot water control, points out that if you want to maintain a temperature at a certain point, the heat-sensitive device should be located at that point.

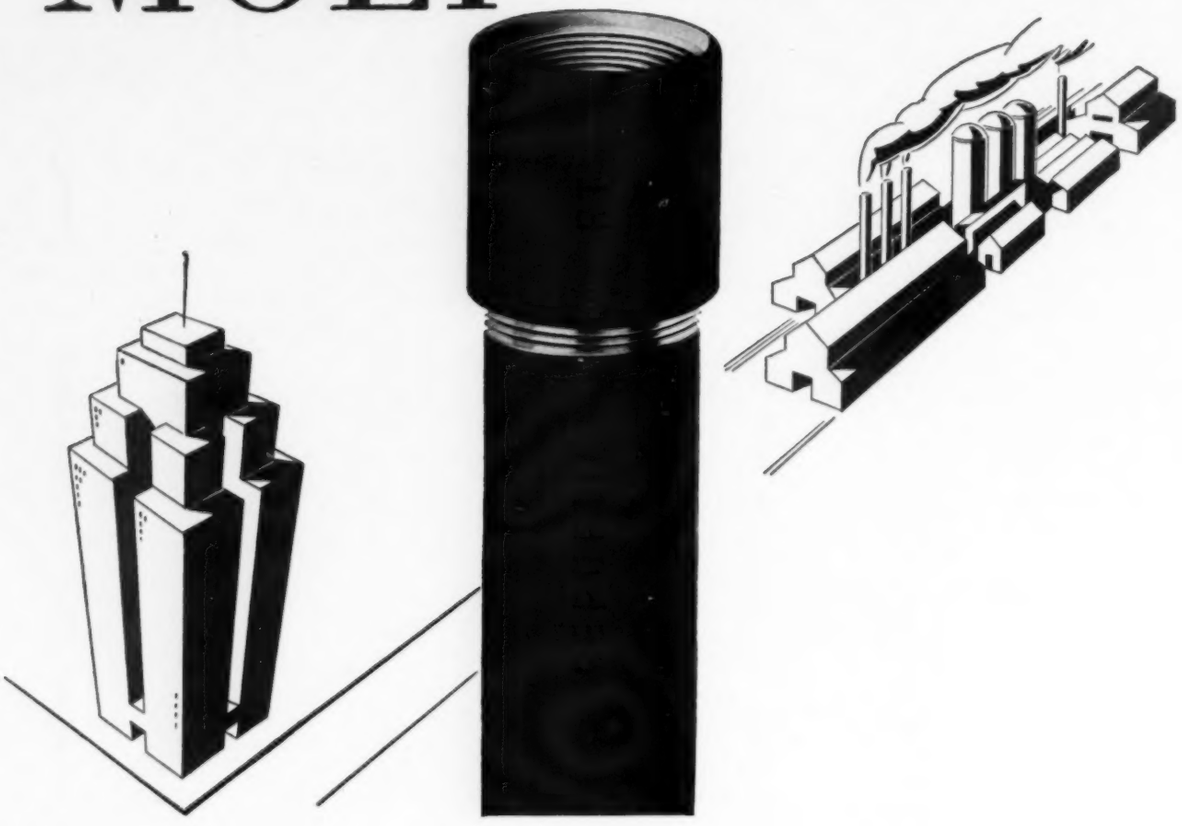
JOURNAL Section of the *American Society of Heating and Ventilating Engineers*—The Journal Section of the *A.S.H.V.E.* includes papers on "The Dust Problem in Air Conditioning," "Air Supply to Classrooms in Relation to Vent Flue Openings," and "Characteristics of Registers and Grilles." Information about the Society's semi-annual meeting later this month also appears.

THE "back of the book" includes the regular departments on equipment developments, new trade literature, book and booklet reviews, convention dates, etc. The coupon on page 92 is for your convenience in getting more information about the new developments mentioned, or copies of the literature on heating, piping and air conditioning issued by manufacturers.

OVER forty representatives of manufacturers of air conditioning equipment met at Hot Springs, Va., last month in a session marked with sound optimism for a substantial increase in volume for 1935, the annual meeting of the *Air Conditioning Manufacturers Association* being the occasion. New officers and directors were elected . . . Air conditioning volume of the Frigidaire Corp. was 302 per cent higher for February of this year as compared with the same month a year ago, leads to the prediction (by that company) that the 1935 dollar volume will be three to five times that of 1934 . . . A Cleveland engineer is estimating five times as many prospective installations as he was last year at this time, says the organ of the *Electrical League of Cleveland* . . . "Business executives are beginning to realize that air conditioning equipment is a worthwhile investment from the standpoint of increased efficiency and daily work output of both employees and officials," according to Walter P. Chrysler, Jr., head of Airtemp, Inc. . . . Instead of closing during the summer, the American theater in Evansville, Ind., now remains open to capacity attendance, according to Westinghouse, whose two 18 ton air conditioning units are the reason . . . Kelvinator air conditioning sales for the first four months of this year were ten times greater than for the same period of 1934, supporting the predictions that 1935 would be a record year . . . All air conditioning manufacturing departments of York Ice Machinery Corp. are working three shifts daily, it was announced last month . . . This company has been commissioned to install a 600 ton system to cool the air for the East Rand Proprietary gold mine at Johannesburg, South Africa, in order that new deposits may be tapped. The equipment, which will cool 150,000 cfm of air, will be installed 6,800 ft below the earth's surface and 2000 gpm of condensing water will be supplied by a subterranean lake . . . Main dining room of the French Line's new flagship, the "Normandie" (world's largest), is air conditioned by means of Carrier equipment.

COMING—Future issues will contain a wealth of heating, piping and air conditioning information now in preparation for publication in H.P.&A.C. . . . Starting next month is a series on air conditioning by L. A. Harding, author of "Mechanical Equipment of Buildings" (with Dr. A. C. Willard), "Heating and Air Conditioning Manual," past president of the *A.S.H.V.E.*, and president of the L. A. Harding Construction Corp. . . . Applications of different types of unit heaters for plant heating and presenting data on temperature gradients from floor to ceiling is to be the subject of an article to appear shortly . . . Building heating economies possible through improved operation and maintenance as well as thermostatic control will be covered in an article which will include data on steam consumption in various types of buildings . . . How a large university keeps its records of steam consumption for building heating, and what steps are taken to insure continual economy in heating cost, will be described by the superintendent of buildings and grounds . . . Piping will be featured in several articles now in preparation, from the design, installation, and maintenance angles; among them is a third article by F. L. Snyder, whose contributions to the January and April, 1935, issues were well received by H.P.&A.C. readers; the first covered flow of fluids and the second flexibility of piping.

"MOLY" *turns the Trick*



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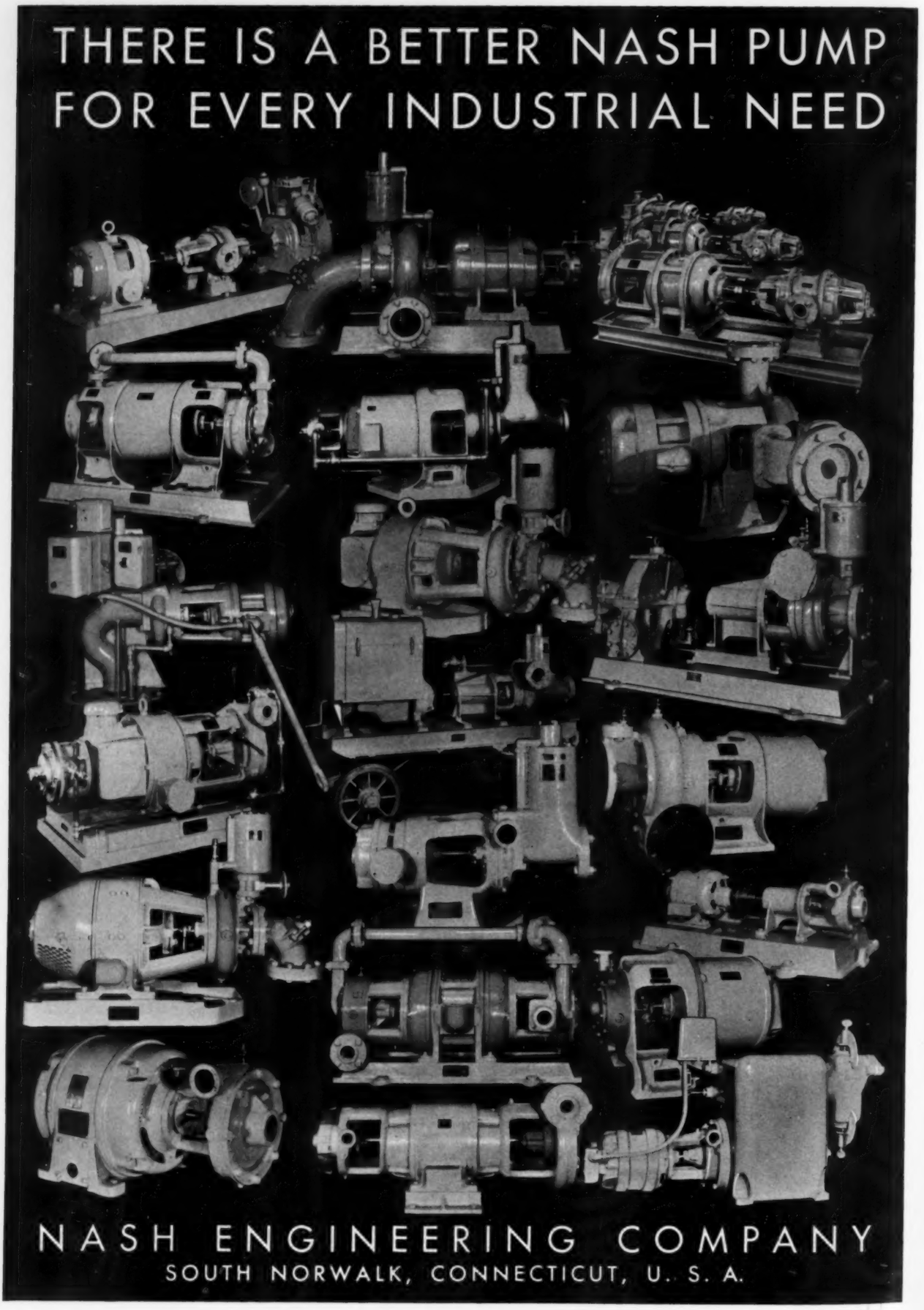
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Heating · Piping and Air Conditioning

Vol. 7, No. 6 • June, 1935

30-Year-Old Museum Modernized

By **Arthur C. Babcock***

THE alteration and reconstruction of the Brooklyn Museum of the Brooklyn Institute of Arts and Sciences, New York, is an outstanding example of large scale modernization of a public building. The remodeling work, which will be completed next month, is interesting as it has demonstrated that old classic buildings can be remodeled and reconstructed at reasonable cost, modern mechanical equipment installed, and the entire building brought up-to-date—yet the modern motif in design need not clash with the old classic treatment if the modernization is carefully planned.

Long considered one of Brooklyn's architectural masterpieces, this limestone faced 6 story structure—a typical example of the classic Roman domed edifice so common in public buildings of the period—was built in 1901. As with most public buildings built 30 years ago, the Museum had become obsolete in many respects. Not only was the interior arrangement uneconomical in use of space and not adaptable to modern exhibition principles, but the old auditorium and balcony, used to capacity for public concerts and lectures, was isolated in the central wing of the building on two levels below the main entrance on the third floor.

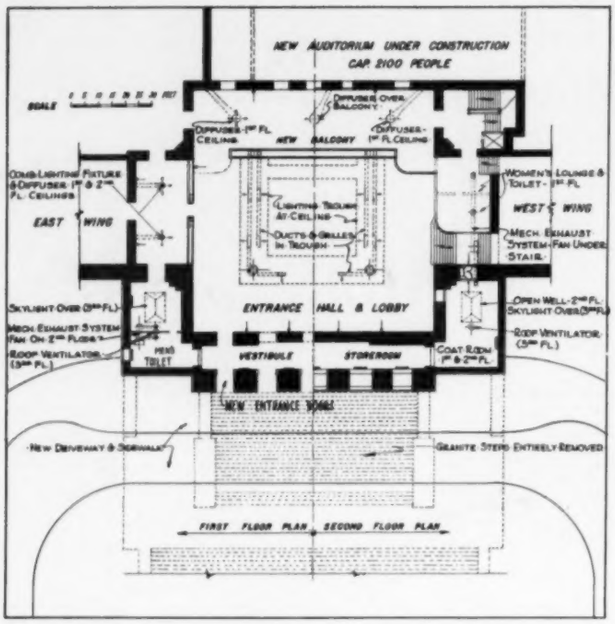
With a view to future developments, additional wings for both arts and sciences, Mr. Philip N. Youtz, the director, made extensive studies of means of preserving the architectural quality of the building and at the same time making the institution a living, useful part of the cultural life of the city. The practical aspect of meeting the needs of a million visitors yearly required the substitution of modern additions, carefully planned lighting, and specially designed heating and ventilating equipment, in place of the original plan of costly extensions of the present classic building with its haphazard lighting and heating facilities. Exhibitions are constantly changing and the inflexibility of ordinary direct and indirect radiation was emphasized by the number of registers shut off, radiators removed and radiator recesses blocked up in the old building over a period of years. The consequent reduction in heating capacity had become serious.

As a result of these studies, the main entrance was dropped to the ground floor by the removal of the entrance steps, the auditorium was removed and remodeled into an entrance hall and lobby and a new auditorium wing leading from the rear of this hall was planned. The alteration was further justified by the extensive repairs in the substructure of the stair itself which would otherwise have been necessary, and the recovery of virtually two floors throughout the building for exhibition purposes. The work included the cutting of new entrance doors through 6 ft of solid masonry, the construction of a new granite and limestone exterior facing and the remodeling of the two lower floors of the building, especially the entrance hall and lobby to serve the present wings, as well as the future extensions to the Museum group.

Construction was started by the Civil Works Administration in April, 1934, and continued by the Works Division, Emergency Relief Bureau of the City of New York. The project was designed by Works Division architects and engineers and carried out entirely with relief labor. Total cost was approximately $200,000, about $40,000 less than the low bid submitted by private contractors a year before for the same work. Total cost of the heating and air conditioning work was about $20,000.

•Extensive remodeling of the Brooklyn Museum demonstrates the possibilities of bringing public buildings of the monumental type up-to-date to better fulfill their functions. . . . Reasons for modernizing. . . . The problems met. . . . How solved.

*Designing Engineer, (Senior Engineer, Works Division, Emergency Relief Bureau, City of New York.)



Plan of alterations

Old Heating and Ventilating System

The old heating and ventilating system consisted of direct connected motor driven blower units in the basement and exhaust fans on the roof, together with the usual pipe tempering coils, dry type air filters and auxiliary equipment. The auditorium space of the two lower floors (90 ft long, 90 ft wide and 24 ft high), which is now the new entrance hall and lobby, was served by a separate tandem, direct connected blower and exhaust unit in the basement installed in 1901.

Distribution of heated air into the auditorium was provided by large ceiling grilles, with additional supply and exhaust in the four walls, some at the ceiling and others at the floor. Considerable direct radiation with cast iron radiators using the old Paul air line system was provided throughout the building.

Heat, light and power is supplied the entire group of buildings from a private steam plant now more than 30 years in continuous service, low pressure steam being utilized for heating and 115 volt direct current for lighting and power.

Indirect lighting cove and air baffle, entrance hall

A comprehensive study of the entire system and its mechanical equipment was made as the first step, and many discrepancies were found in the actual conditions as compared with the old drawings, especially in the layout and location of the large amount of ductwork. This survey showed that many changes for which no records were available had been made in the intervening years.

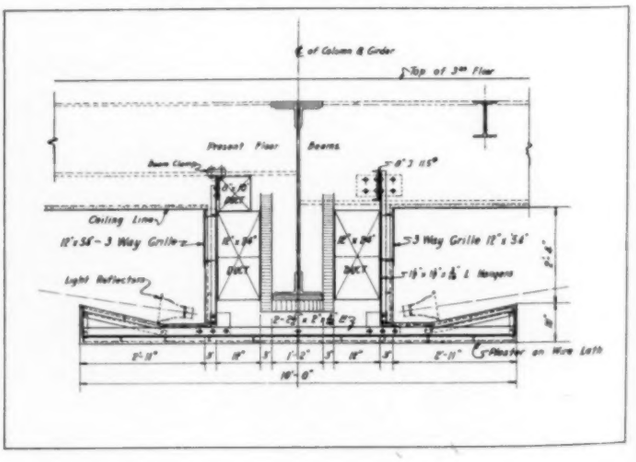
Design of the New System

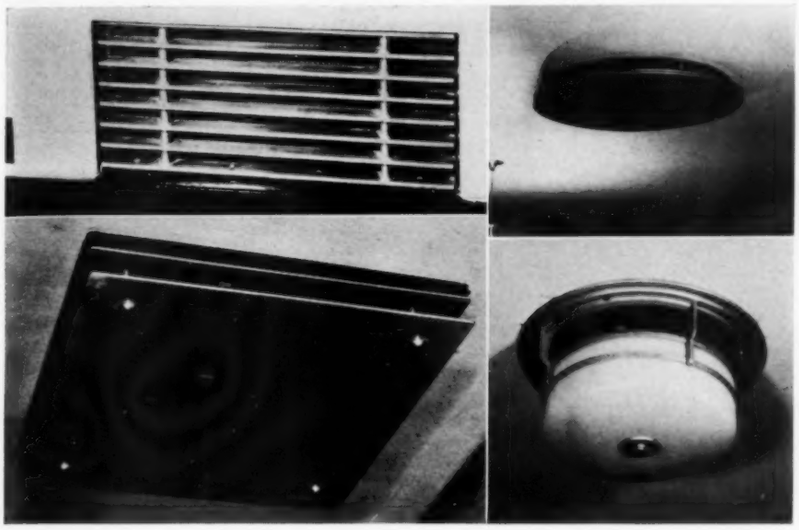
The problem was to convert an obsolete 30 year old heating and ventilating system into a modern system which could be later adapted to complete air conditioning when funds become available. Maintenance of proper temperatures and humidities is considered of prime importance in museum buildings today, not so much for the comfort of visitors as for the preservation of valuable paintings, drapes and other exhibits.

Inasmuch as the old system was of the upflow type and any extensive alteration of the ducts would have been too costly, it was decided to make only the system in the new entrance hall of the downflow type (since this space was served by an independent recirculating unit in the basement) and to retain the upper floor system as originally built. The new design was complicated by the architectural layout of the entrance hall which necessitated removing practically all the ductwork in the two lower floors. The risers serving the upper floors furred out on the outside walls, together with the steam risers, had to be relocated in cramped spaces between the new doors which reduced the available clearance 40 per cent. In the final design it was necessary to abandon 10 per cent of the old duct area because the cost of alteration would have been excessive. The decrease in volume was compensated for by increasing the velocity of flow in some of the remaining ducts.

Inspection and tests of the old fan units showed them to be in surprisingly good mechanical condition despite their 30 years of constant service and they are being used for the new system. These units were also of sufficient capacity for the new system since the air requirements have not been materially increased. Minor

Typical section through lighting trough





Grilles, diffusers, convector plates and other fixtures were regarded as integral parts of the architectural treatment. Upper left—Aluminum ventilating grille. Lower left—Aluminum plate grille, toilet room system. Upper right—Ceiling disc diffuser; black formica panel with aluminum inlaid bands and chromium bolts. Lower right—Aluminum lighting fixture and outlet grille.

replacements were made in the blower units, new heating stacks were installed to replace the old pipe coils and a new set of dry type filter units completed the present equipment. An air washer is to be installed later and dehumidifying and refrigeration equipment will convert the plant into an economical air conditioning system, with slight changes in the basement headers.

Two separate fans exhausting directly to atmosphere ventilate the toilet and lounge rooms. The direct radiation of the entire building was changed over from the Paul air line to a modern vacuum heating system by the installation of new valves, thermostatic traps and vacuum return pump.

No changes were made in the power plant because it is to be completely rebuilt.

Construction Details of New System

Since much of the ductwork was changed the velocity, flow, volume and equilibrium characteristics of the system were unbalanced; to insure the correct proportioning of the air, dampers were inserted and set by actual trial tests.

Ducts are copper bearing steel sheets and outside exhaust hoods and ventilators are 16 oz. copper. Ducts were not painted but were insulated against heat loss where required. Fans were silenced by isolation and canvas sleeves.

In designing grilles, diffusers, convector plates and other fixtures, the policy was established that their presence should be accentuated and made to stand out as integral parts of the architectural treatment rather than to attempt to camouflage or conceal these necessary accessories. Original and simple designs were developed which, while serving their utilitarian function, also enhance the modern interior treatment of the new entrance hall.

Simplicity, bold lines and minimum superficial adornment were carried out in these designs. Grilles and other fixtures were finished in polished aluminum while those in the front wall in a wainscot of black Carrara glass are of a specially processed aluminum producing a black finish that harmonizes perfectly with the polished black glass. The ceiling disc diffuser illustrated is typical of the general treatment. Molded of black formica panels with inlaid aluminum bands and chrome plated bolts, the fixtures are examples of the designer's belief that the exposed elements of a heating and ventilating system have as much claim to architectural beauty as have lighting or other fixtures.

Design Data, Brooklyn Museum

Design Temperatures—Outside—9 F + 15 F = 6 F.
Inside 65 F at breathing line.

Ventilation Rate—Entrance hall and vestibule, 3 air changes per hr.
Toilets and lounges, 10 air changes per hr.

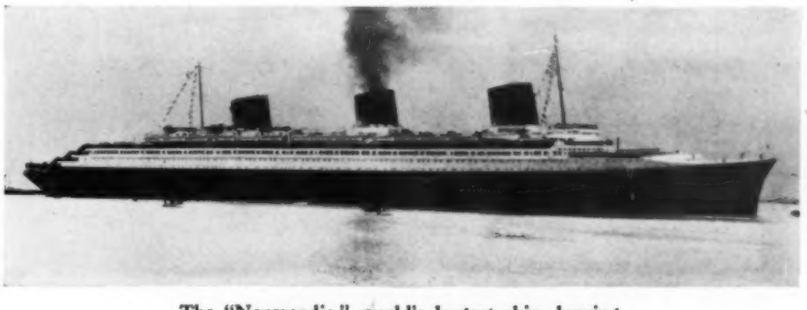
Type of System—Entrance hall: Central fan, downflow, heating and ventilating.
Vestibule: Heating by concealed gravity convectors, ventilation by infiltration.
Toilets and lounges: Heating by direct radiation, independent mechanical exhaust ventilation.
Coatroom, storerooms, etc.: Heating by direct radiation, ventilation by dampered roof ventilators.

Estimated Ventilation Requirement

Entrance Hall: 10,000 cfm with 80% mechanical exhaust.

Duct Velocities—Horizontal ducts; Max. 1,000 fpm.
Vertical: 700 fpm.
Supply grilles: 300-400 fpm.
Exhaust grilles: 300 fpm.

The vast dining room of the French Line's new flagship is completely air conditioned, air being introduced by openings concealed behind the moulded art glass panels which comprise the more than 8000 sq ft of wall on each side of the room. The dining room is entirely "windowless," is nearly 300 ft long and three full decks high; its width is 45 ft, or 67 ft including the private dining rooms.



The "Normandie," world's largest ship, leaving Saint-Nazaire for tests off the coast of Brittany

PIPE WELDING—
Practical Field Testing and Instruction of Welders

By **D. O. Ferguson***

•A program of welding instruction and testing based on the idea of helping the welder, providing for his development, and insuring good pipe welding is described in this practical paper.

THIS paper is intended to cover "Pipe Welding" only, and is devoted entirely to that division of welding. The technique of welding is not touched upon to any great extent, but rather the methods of making the field tests and instructing the welders. We use the same methods for testing and instructing both oxy-acetylene and electric arc pipe welders, so that this discussion can be considered as applying to both processes.

It should be remembered that the tests which we make are "field tests," and must necessarily be of a nature which can be made in the field. We do not disagree with the standard laboratory tests in any way, but we have modified these tests to some extent so that they can be performed in the field and so that the results of the tests can be made available in a comparatively short time.

The program which we follow is very simple, and is kept purposely so. It is designed to provide a maximum amount of welding instruction, and a minimum amount of weld testing.

I believe that the simplest way to explain our program is to tell in detail how we deal with the welders in the field.

Preliminary Remarks to Welders

Each welder at the time of our original contact with him is required to make up the various types of welds with which he is familiar. Nipples 6 in. long from a standard 6 in. pipe are generally welded together for these tests; we have found that 6 in. pipe provides an adequate wall thickness and an adequate "swing out" if a position weld is being made. These welds are made *without* any instruction from us whatsoever, and it is important to remember that the welder is only asked to make the types of welds with which he is familiar. The welders are very apt to ask us how much reinforcement we want, how much spacing, how much beveling, what size of filler rod, etc., but they are specifically told to make the welds exactly like they would make them if they were "50 miles away from any one besides their helper." No time limit is set for completion of the weld, and the welder is permitted to select the size of welding head, oxygen and acetylene pressures, and size of welding rod if the oxy-acetylene welding process is used; or the amperage, voltage, and size of electrode if the electric arc welding process is used.

The welder is also told that we are going to test his welds; and that we expect them to develop joints which are, on the average, 90 per cent as strong as the pipe material. An exception is made when the pipe develops a tensile strength of 60,000 lb per sq in. or over. In this event, we require an average tensile strength of 55,000 lb per sq in., and a minimum tensile strength of 50,000 lb per sq. in.

Summing up, I might say that we impress upon the welder that he—and he alone—is responsible for the quality of the test welds; and that when he turns them over to us for testing, they are supposed to represent his idea of first-class welds. We go to considerable trouble to tell the welder that we want a first-class job, and also to impress upon him that the weld which he is making is based on *his* idea of a first-class job. The detail to which we go in our "preliminary remarks to the welders" has been responsible for eliminating alibis later on if the preliminary welds fail to meet our specifications for satisfactory welding.

Types of Welds Made and Tested

The following types of welds are generally made and tested:

Rolling Weld—The pipe is turned as the welding progresses.

Position or tie-in Weld—The pipe is held in a fixed horizontal position. The weld is started on the bottom of the pipe and carried up one side, after which the welder returns to the bottom and welds up the other side, finishing the weld on top of the pipe.

Vertical Weld—The pipe is set up in a vertical position, and the weld is made around the pipe. This is really a horizontal weld, but most of our welders call this type of weld a "vertical weld", so we have adopted their terminology.

45 deg Position Weld—The pipe is inclined at an angle of approximately 45 deg, and held in this position. In this case, the weld is also started at the bottom of the pipe and welded up one side to the top, after which the weld is carried from the bottom to the top on the other side, finishing the weld on top of the pipe.

Backhand Weld—In case the oxy-acetylene process of welding is used, this type of weld is sometimes made and tested. It differs from the regular rolling weld in that a different technique of rod and flame manipulation is used. The rod is carried back of the flame, instead of ahead of the flame as in the case when the regular forehand, or ripple, oxy-acetylene weld is made. The pipe is also turned as the welding progresses.

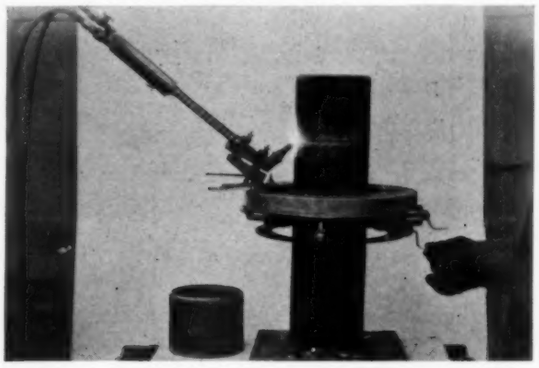
All of the welders do not make all of these types of welds because in the original test of the welders, we

*Welding Engineer, The Ohio Fuel Gas Co., Columbus Ohio.
Presented at the Fourth Annual Welding Conference, Department of Industrial Engineering, The Ohio State University, Columbus, Ohio.

insist that they make only the types of welds with which they are familiar; and, naturally, we find some welders familiar with a greater number of types of welds than others. It should be distinctly understood that we are trying to form an opinion of the ability of each welder before commencing welding instruction.

Preparation of Coupons

After the welds are completed, they are prepared for testing by the portable coupon cutting machine which was developed in one of our shops. This machine is a decided help to us because it prepares the coupons rapidly and economically, and *usually* enables us to test each weld in the presence of the welder who made it.



Beveling test specimens with the pipe beveling device developed by T. J. Thatcher at the Columbus shop of The Ohio Fuel Gas Co., as was the coupon cutting machine. One specimen has been beveled prior to welding, and the other specimen is in the act of being beveled. This view shows that the beveling machine can be used with the pipe in a vertical position, and also that a simple attachment can be made so that the beveling machine is able to use a standard cutting torch. A regular cutting blow pipe is being used

It also enables us to test the weld before the welder forgets how he made the weld, and whether or not he was having any particular difficulty in making it.

After the coupons are cut out, they are stenciled with a steel stamp for identification during the test, and also for identification on the reports which are sent out to the welding supervisors after the test.

Seven coupons, or small strips of pipe running lengthwise of the welded specimen, at right angles to the weld, and containing a portion of the weld, are cut from each welded specimen. In the case of test welds, these coupons are purposely cut from what we think are the worst sections of the weld with one exception.

This exception has to do with the location of the "nick break" coupon. This coupon is always taken from the finish, or seal, of the weld.

In addition to the "nick break" coupon (which as its name indicates is nicked and broken), six additional coupons are taken from each welded specimen. Four of these coupons are tested for tensile strength, one is tested for ductility of the weld metal, and one is given a "reverse bend."

Tests of Welded Coupons

Nick Break Test

The "nick break" coupon, with the weld reinforcement intact, is "nicked" either with a cutting torch or with a hack saw; and is clamped in a vise and struck a sharp blow with a hammer from the back side of the weld (opposite the face of the weld). The fractured coupon is then examined visually for weld defects, and is graded as "Excellent," "Good," "Fair," "Poor," or "Very Poor" depending upon the defects which may, or may not, be present.

Tensile Test

The four tensile coupons are measured as to width and thickness of pipe, and the cross-sectional area of the *pipe* coupon is calculated. It is important to remember that we *do not* measure the cross-sectional area of the weld, and that we also *do not* remove the weld reinforcement from the tensile coupons. In other words, we are trying to determine the efficiency of the joint as a joint—and *not* the tensile strength of a square inch of deposited weld metal.

After the tensile coupons are measured, they are pulled to destruction in a portable tensile testing machine; and the total pull, as recorded on the dial of this machine, is read. If the dial reads 15,000 lb, and the cross-sectional area of the pipe is ¼ of 1 sq in., obviously a 60,000 lb per sq in. tensile strength has been developed. This may mean two things, depending on whether the pipe or the weld fails. If the weld fails, it means that a weld of this quality would be just sufficient to break 60,000 lb pipe; while if the pipe breaks outside the weld, it means that the weld was stronger than 60,000 lb pipe.

While this explanation may seem needless, I think it is important because we refer to welds as being 50,000, 60,000, or 70,000 lb welds, which merely means that they are strong enough to break 50,000, 60,000, or 70,000 lb pipe, and *does not* take into consideration to any extent the cross-sectional area of the weld.

Ductility or Free Bend Test

The weld reinforcement is removed from one coupon, and two small punch marks ½ in. apart are placed on the face of the weld wholly within the weld metal area. This coupon is squeezed in a vise so that the bend occurs within the weld, and the outside of the weld is stretched. This squeezing is continued until a bend of 180 deg is obtained, or a fracture occurs. The increase in the distance between the two punch marks is meas-

Welding a specimen for testing by the backhand method. After this specimen is welded, it will be mounted in the coupon cutting machine and the coupons will be removed

THE program described here is carried on continuously, and has been for almost three years, in the Columbus Group of the Columbia System, which is operated by The Ohio Fuel Gas Company. There are approximately sixty oxy-acetylene welders, and about six electric arc welders in this group. The work the welders do is generally pipe welding; that is, distribution, transmission, and well lines, also piping of all kinds in connection with compressor stations. The regulators for the distribution systems are practically 100 per cent welded, and welding is used to a large extent for a great number of repairs.

Success of such a program is largely dependent upon the proper equipment, practically all of which, with the exception of the testing machine, was developed in the company's Columbus shop by T. J. Thatcher. The beveling machine is used widely, about fifteen or twenty of these machines being used. The machine is portable, weighing approximately thirty pounds, and will bevel pipe in sizes from 2 to 8 in. It is particularly advantageous as it enables reconditioning well casing for re-use.

The torch coupon cutting machine has solved the problems in connection with having coupons prepared for testing. At the start of the program, the work was hampered because of the necessity of taking coupons to the machine shop for preparation. This entailed delay as well as considerable expense, approximately $80.00 a month being the cost of machine shop work in connection with preparing coupons. Now it is possible to prepare a set of coupons in approximately five minutes after the specimen has been mounted in the coupon machine.

ured, and recorded as inches of elongation in ½ in. of weld metal.

Reverse Bend Test

The seventh and last coupon, with the weld reinforcement intact, is placed in a vise and struck with a hammer from the back side of the weld (opposite the face of the weld). This coupon is bent to an angle of 90 deg, or until a fracture occurs.

All of the operations, as mentioned before, are performed in the presence of the welders, *if possible.* Sometimes it is necessary to perform the free bend or ductility tests after the welders have gone home, particularly if we are testing a large number of welders. The free bend or ductility coupons require grinding to remove the weld reinforcement; and if pressed for time, we make the ductility tests after working hours and show the results of these tests to the welders the following day.

After the welders have been tested, as described before, they are passed for the particular type of welding for which they qualify, or they are temporarily rejected and scheduled for immediate welding instruction. The testing, as described, and our recommendations for satisfactory welding, which follow, may seem to indicate that we take up a great deal more time for testing than we do for welding instruction. I can assure you that such is not the case; and the welders will generally make, depending upon their experience of course, anywhere from four to fifteen times as many welded specimens under our supervision as they make in the preliminary tests, that is, tests with no instruction or no supervision by us.

Requirements for a Satisfactory Weld

Nick Break Test

Freedom from serious defects as disclosed by a visual examination, and a grading of "Fair" or better.

Cold laps are likely to occur where the weld is finished due to lapping over the start without bringing it to the proper fusing temperature before depositing the rod metal.

Insufficient fusion, that is, a lack of proper fusion to the sides of the pipe wall, is also likely to occur here on account of the welder getting what we call a "cold start."

The location of the nick break coupon is planned to find such defects.

Tensile Test

An average tensile strength of four coupons of not less than 90 per cent of the tensile strength of the pipe; unless, as explained before, the pipe is 60,000 lb or over. In that case, we require an average of 55,000 lb per sq in.

The minimum coupon of the four tensile coupons must develop a tensile strength of not less than 85 per cent of the tensile strength of the pipe unless the pipe is 60,000 lb or over. In that case, we require a minimum tensile strength of 50,000 lb per sq in. The minimum strength is specified in order to obtain a uniform weld, and to prevent three very good coupons from overcoming the effects of one bad coupon.

Ductility or Free Bend Test

One-eighth of an inch elongation in ½ in. of weld metal. This means, of course, 25 per cent, but we record it as inches of elongation in ½ in. of weld metal for simplicity.

I might point out at this time that I have seen tests made, and elongation calculated, using punch marks 2 in. apart, including both weld metal and parent metal. In my estimation, this procedure is entirely wrong as undoubtedly some stretch takes place in the parent metal and is recorded as ductility of the weld, when, as a matter of fact, the quality of the weld should not be judged by the stretch taking place outside the weld.

I might also say that I consider that our free bend requirement is rather easy to pass; and that we are considering an increase in this requirement to three-sixteenths of an inch elongation in ½ in. of weld metal, instead of the present specification of ⅛ in. elongation.

Reverse Bend Test

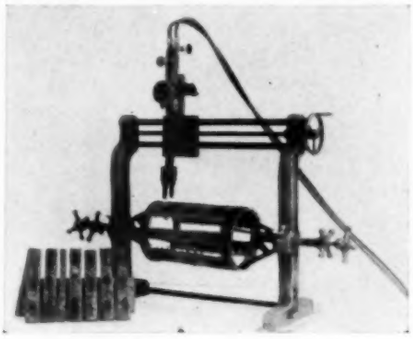
A 90 deg backward bend without fracture.

This test is particularly severe on coupons when the weld does not reach through the pipe (insufficient penetration), or when an area of insufficient fusion occurs at the extreme bottom of the weld.

We feel that our requirements for satisfactory welding are severe for the class of work we are doing, but

we have made them severe purposely. We want requirements which will make even a good welder extend himself, and we also want requirements which will provide for a "slip back" as we are not foolish enough to believe that we always obtain production welds made to the best of the welder's ability.

Only recently have the welders had an opportunity to see the inside of their welds, and to learn the mechanical strength of the joints which they make. Most



The coupon cutting machine showing a welded specimen mounted in the machine with the seven coupons which were used for testing removed from the specimen

Testing a coupon with a portable tensile testing machine. One coupon is in the machine, two coupons have been tested and the illustration shows that the strength of these welds has exceeded the strength of the pipe. The remaining tensile coupons are shown prior to placing them in the testing machine. The nick break, reverse bend, and ductility coupons are also shown

welders and welding supervisors judge the quality of the welds solely by the failure, or non-failure, of the weld under service conditions. At first thought, this method may seem to have its good points; but it does not take into consideration any need for a factor of safety. While it is true that many welds which are only from 25 to 50 per cent as strong as the pipe material will serve a useful life, this behavior is generally due to the fact that they are never called upon to take any great amount of strain.

Unfortunately, such conditions do not always prevail; and it is our judgment that all welds should not be made just strong enough to withstand service conditions, but *should* contain an ample factor of safety, such as all properly designed bridges, structures, machinery, valves, etc., have. We think it not unreasonable to require this factor of safety, especially since it can be easily obtained by proper welding procedure at practically no increase in the cost of the welded article.

Welding Instruction

After the preliminary welds are made, they are tested as soon as practical in the presence of the welder who made them. The defects, if there are any, are pointed out to the welder, and specific recommendations are made to eliminate them.

Each welder requiring help is then given immediate detailed instruction by my assistant. This instruction is individual, and is designed to cover the particular trouble which the welder in question may be having. This instruction consists of sitting down, or laying down, as the case may be, with each welder and watching his welding technique in detail. If the welder is working improperly, the instructor will take the torch, or electrode, as the case may be, and will weld a short distance for him. They will trade then back and forth until the problem is worked out, or until we are thoroughly convinced that the welder will not be apt to qualify during this visit. Many of these welds will not be tested due to the fact that the instructor may have helped make part of them, or because we do not think them worth the expense and time of testing.

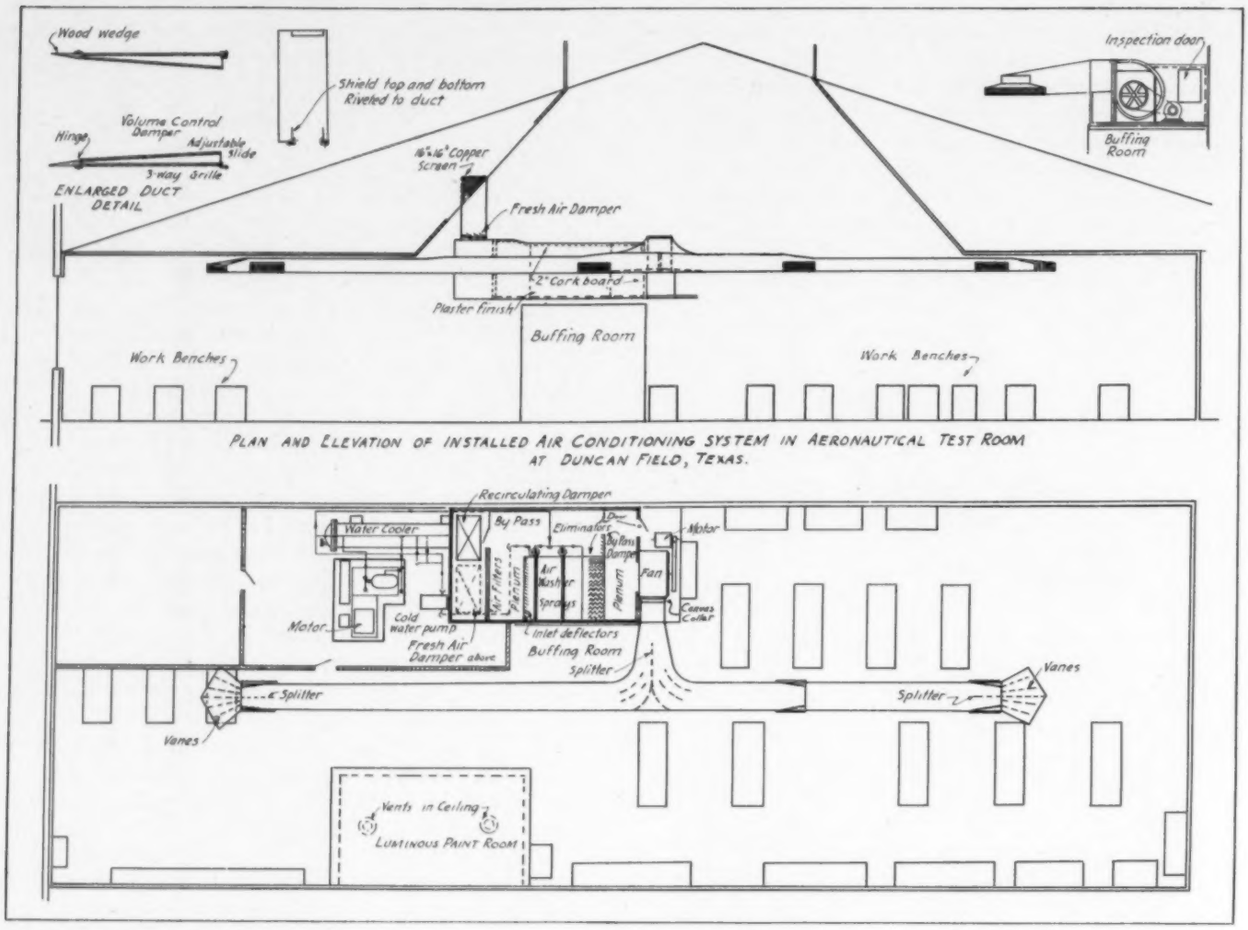
I do not mean to say that all the welders whom we test need instruction. On the contrary, some of them do very well in the preliminary tests, and are qualified by us without receiving *any* welding instruction. Some of them need only to see the defects as shown to them by the preliminary test, and they are then able to eliminate these defects without any further help from us. However, some of the least experienced welders may need repeated welding instruction, follow-up tests, and additional instruction before we consider it safe to allow them to weld.

While the instruction described may not seem very long, I might say that many times we will discover defects in one preliminary weld in an hour or two; and that it will require several days to overcome these defects successfully.

[The second part of this paper will discuss the classification of welders, follow-up tests, reports to welding supervisors, and office records.—Ed.]

In building modernization, air conditioning is a profitable and often necessary addition. For example, White's tea room, Richmond, Va., installed air conditioning in 1933 and attributes a 50 per cent increase in summer business to it. The equipment is operated from 8 a.m. to 12 p.m. every day, four to five months per year. Initial cost was $4000 with $85 to $90 a month operating costs. Before air conditioning, White's served approximately 700 meals a day in the summer with an average check of 32 cents; now they serve 1,000 to 1,200 meals a day with a check of 36 cents.

Business of the Kansan Hotel, Topeka, doubled after air conditioning the restaurant. The equipment is operated 100 days a year, 10 hours a day. The installation cost approximately $3,000.—S. F. Myers, Manager Air Conditioning Sales, Westinghouse Electric & Mfg. Co.



Air Conditioning Protects Aeronautical Instruments

By **A. J. Rummel***

●Air conditioning system maintains comfortable working conditions in aeronautical repair and test room, guards important instruments from dust and dirt. . . . Room is isolated from rest of building. . . . The air conditioning system and method of control

RECENT installation of an air conditioning system in the aeronautical repair and test room of the San Antonio Air Depot at Duncan Field, Texas, provides the air conditions necessary for the perfect balancing of sensitive aeronautical instruments. Since the removal of dust and dirt is of major importance, all air is passed through filters before being delivered to the room. As it is also necessary to eliminate air motion, the room is kept tightly closed and is maintained under a slight pressure so that air leakage will be outward. In summer the heat liberated in the room, plus heat transmitted through the building, would therefore result in uncomfortable working conditions for the nine occupants if cooling were not employed.

In the room are tested, repaired, and overhauled the compasses, climb indicators, altimeters, bank and turn indicators, air speed indicators, clocks, pressure gauges, flight indicators, and directional gyros for 600 airplanes. Considerable progress has been made in the design and use of flight indicators and directional gyros. These instruments are used to determine the position and course of the plane when flying blind. They are now looked upon as standard equipment and used in considerable numbers, where formerly they were used in limited numbers and were returned to the factory when repairs were necessary. The directional gyros operate at between 11,000 and 12,000 rpm and are tested under a microscope to insure perfect bearings and balance. The slightest amount of dust or lint will cause the instruments to be out of balance.

42 Ton Compressor Installed

The air conditioning system comprises a 42 ton compressor, cooling coils, filters, blower, water spray, in-

[*Continued on page 289*]

*Air Conditioning Engineer, San Antonio Public Service Co.

World's Highest Air Conditioning System

By A. B. Wason*

The "world's highest" air conditioning system serves the main offices of the American Cyanamid Co. on the 57th to 61st floors of the R. C. A. building, New York City. The system is the central station type with booster fans, each arranged with isolated bypass recirculation. Refrigeration is furnished by a 180-ton centrifugal water vapor machine. . . . The unusual problems met in the design and installation of this interesting system and their solution are described here, and operating and cost data are reported.

Seventy story R. C. A. building, Rockefeller Center, New York; the air conditioned offices of the American Cyanamid Co. are on the 57th to 61st floors. Design and installation of the air conditioning system presented unusual problems, as all equipment had to be located within these floors

THE "world's highest" complete air conditioning system is in the new main offices of the American Cyanamid Co. on the 57th to 61st floors of the 70 story R. C. A. building, Rockefeller Center, New York City. All the equipment—including the mechanical refrigeration—is installed between these floors. Francis Y. Joannes, New York, was the architect and Jaros, Baum and Bolles, New York, were consulting engineers.

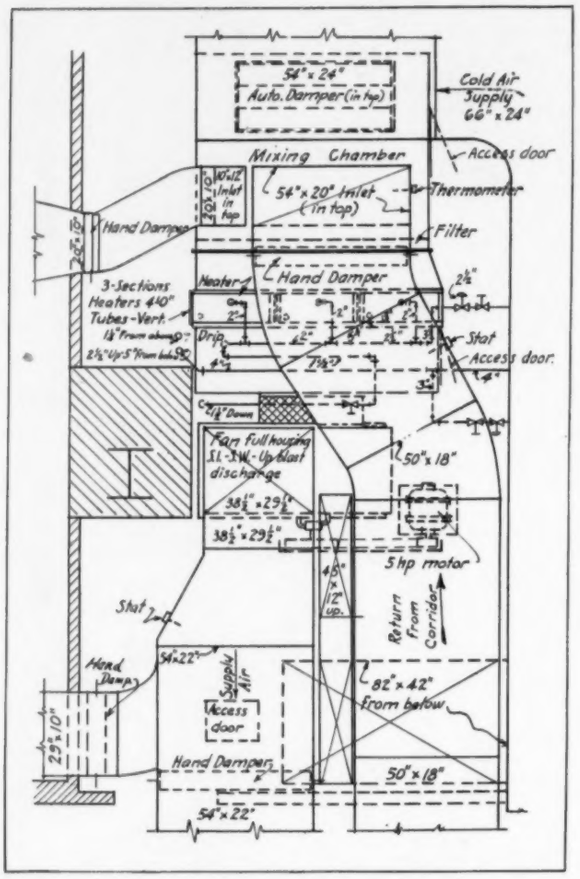
The entire 58th, 59th and 60th floors and portions of the 57th and 61st floors were leased without any interior partitions in order to meet the special needs of the tenant. The building is 316 ft long, 105 ft wide and 850 ft high, with windows on four sides; the central portion is used for elevators, stairwells, fire tower, ventilating ducts, pipe shafts and service spaces. Many problems faced the architect and consulting engineers in designing an air conditioning system to minimize floor space requirements for apparatus and stay within the leased areas, and considerable study of the building spaces was made to subdivide to suit the tenant. The final layout decided upon subdivided the leased spaces into 165 rooms, varying in size from a single private room to large clerical spaces, with corridors, communicating stairs between floors, interior storage spaces, closets and reception rooms.

From an air conditioning standpoint, the problem was to distribute air, properly conditioned and cleaned, throughout each room and corridor and to maintain the air in each room at an even temperature, yet within a reasonable degree of the outside atmosphere which is essential to comfort. The long dimension of the building faces north and south, which introduced a serious cooling problem due to solar heat on the southern exposure.

The design was solved by zoning the conditioned areas by outside exposures, each air conditioning sys-

*Engineer, The Cooling & Air Conditioning Corp., New York, N. Y.

tem being divided to meet the exposure requirements. Thus a central station dehumidifier on the 59th floor supplying cold conditioned air to each of nine booster systems on various floors from the 57th to 61st is used. Conditioned air is distributed through sheet metal ducts above corridors. Recirculated air from each room is returned through ducts or through louvre doors to corridors from each zone, back to the bypass connection at the booster fan for each exposure on each floor. This is known as a central station system with booster fans,



Typical booster fan arrangement

each arranged with isolated bypass recirculation, as licensed under patents.

The refrigeration also presented problems. Code regulations excluded all refrigerants at this elevation except air and water. Thus only two types of refrigeration—steam jet and centrifugal water vapor—were considered. As the refrigeration equipment is situated on the 58th floor 650 ft above the sidewalk, and as steam at the pressure and in quantities required for steam jet units was not available or possible to obtain because of no available space in the pipe shafts, centrifugal water vapor refrigeration was used to meet the special requirements. The refrigeration machine cools water to 50 F which is sprayed through the mist type nozzles in the conditioner on the 59th floor.

Between the 58th and 59th floors is a pipe gallery; this added story height was utilized by removing the floor slab, giving 18 ft headroom space to accommodate a 180 ton refrigeration plant. However, the problem was still only partly solved, as the load requirements could not exceed the design of the building column steel. The refrigeration plant therefore had to be specially designed so that the live load did not exceed 36,000 lb.

City water for condensing purposes was not available nor obtainable at this height and a cooling tower of the air washer type was therefore installed. This condenser water cooling system draws outside air from the north side of the building through two banks of mist type nozzles and discharges into atmosphere on the south side. All this equipment is within leased areas.

The cooling tower discharge air had to be such that under no outside atmospheric conditions would the hot, humid, saturated discharge air condense, causing a fog to appear high up on the outside of the building, which would be very objectionable.

The Central Station Air Conditioning System

The central station air conditioning system on the 59th floor consists of the main supply fan handling 51,000 cfm driven by a 20 hp a-c slip ring motor with a short center belt drive, special dehumidifier, fresh air heaters and dampers.

Fresh air is taken in through louvres and screen on the north side of building 680 ft above the street, drawn through heaters in pipe gallery, mixed with recirculated air at inlet to the dehumidifier on 59th floor and conditioned to proper requirements. This primary fan No. 2 discharges saturated air at 50 F through insulated cold air supply ducts to nine booster units located as follows:

Booster fan No. 3—located in pipe gallery—supplies west exposure 57th floor.
Booster fan No. 4—located in pipe gallery—supplies west exposure 58th floor.
Booster fan No. 5—located in pipe gallery—supplies north exposure 58th floor.
Booster fan No. 6—located in pipe gallery—supplies south exposure 58th floor.
Booster fan No. 7—located on 60th floor—supplies north exposure 59th floor.
Booster fan No. 8—located on 60th floor—supplies south exposure 59th floor.
Booster fan No. 9—located on 60th floor—supplies north exposure 60th floor.
Booster fan No. 10—located on 60th floor—supplies south exposure 60th floor.
Booster fan No. 11—located on 61st floor—supplies west exposure 61st floor.

Typical Booster Fan Room Layout

Cold conditioned supply air is mixed with recirculated air in the mixing chamber and drawn through filters of the spun glass cell type and heaters of fin type by a booster fan handling 12,000 cfm driven by a 3 hp constant speed motor, and discharged through distributing duct system. With this arrangement, the booster fans operate on low static pressure to give a saving in horsepower, low outlet velocities and quiet operation.

Distribution of Air

One of the most important features of any air conditioning system is proper air distribution. No matter how efficiently the equipment may function, if the air is not distributed properly the results are not satisfactory.

Conditioned air must be supplied to all points with positive circulation. *In no case is an air conditioning system better than the air distribution.*

The problems of good distribution are different for every building, and a thorough study of the special conditions, based on a combination of engineering knowledge and practical experience, was therefore made. The supply ducts are installed overhead in the corridors with supply outlets at the ceiling to each room. Return air is circulated through louvred doors in each room into corridors and returned to booster fan units. In the executive offices both supply and return air ducts were installed for each room.

The air supply outlets are placed so that if at any future time interior partitions are relocated, enlarging or reducing rooms, the distributing system will not be affected. In case a cross partition is installed only a short duct extension is necessary.

Special supply grilles were designed for diffusing the air in each room with angular vanes so that a stream of cool conditioned air delivered at the ceiling discharges toward the outside surfaces to assure comfortable maintained conditions free from noise and drafts.

Centrifugal Water Vapor Refrigerating Plant

Water vapor refrigeration is many years old in principle, but has but recently been applied extensively to air conditioning. Water itself is the refrigerant, a small percentage of which is evaporated at high vacuum; the vapor is compressed by a multi-stage compressor and discharged to a condenser. To obtain a boiling or evaporating temperature at 50 F, for example, it is necessary to reduce the water vapor pressure to 0.36 in. of mercury, equivalent to a vacuum of 29.64 in. Therefore, vacuum within a small fraction of an inch has to be maintained in the evaporating vessel.

Part of the water entering the evaporator flashes into vapor having an enormous volume. The water vapor itself has to be compressed to a pressure at which it will condense with water at ordinary temperatures available. The volume per lb of steam at 29.64 in. (corresponding to 50 F) vacuum is 1,705 cu ft, which requires handling 35,000 cfm to develop 100 tons of refrigeration. Owing to direct evaporation, the horsepower required is a theoretical minimum.

The volumetric capacity of the water vapor centrifugal compressor is a constant, but by increasing the chilled water temperature 3 to 5 F the refrigeration capacity will increase 15 to 25 per cent. Because of this sustained capacity and overload capacity, this refrigeration unit is rated at full tonnage (180). As chilled water temperatures are reduced, tonnage capacity is correspondingly reduced.

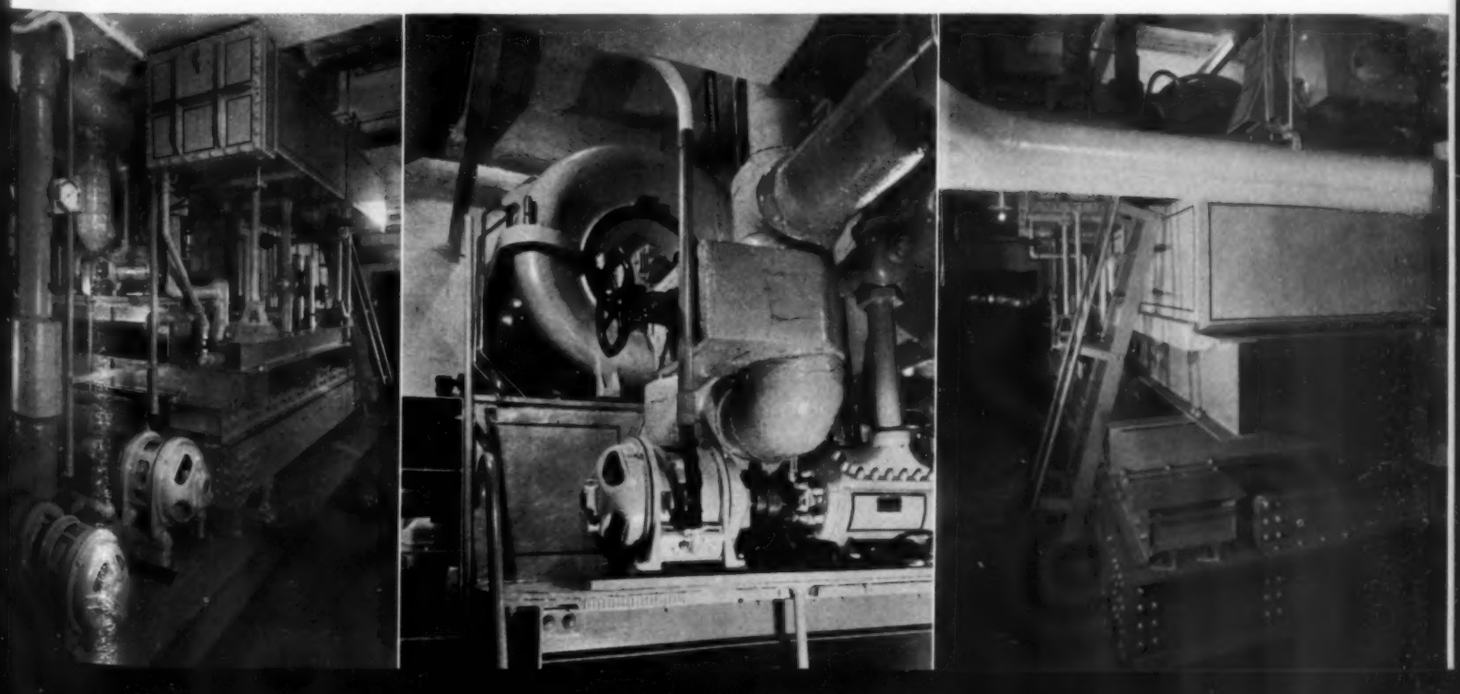
The water vapor refrigeration plant was designed to develop 180 tons at a 50 F chilled water temperature; it consists of centrifugal multi-stage compressor running at 7300 rpm, direct connected through reducing gears to a 150 hp 1800 rpm a-c motor wound for 3 phase, 60 cycle, 208 volts, all mounted directly above the evaporator. The compressor discharges into a shell and tube condenser bolted directly to the compressor discharge flange. A vacuum purge pump is mounted on one end of the evaporator.

A pump draws the chilled water from the evaporator against the vacuum and discharges into the suction of another chilled water pump which pumps to two banks of mist type spray nozzles in the dehumidifier on the 59th floor. The water returns through overflow to evaporator inlet.

The water vapor centrifugal refrigeration unit has the characteristic of automatically following the refrigeration load and the power consumption automatically reduces at partial loads, approximately in proportion to the tonnage. No speed variation, hand adjustments, or special controls are required except inlet water control valve when starting up.

It is interesting to note that this centrifugal water vapor unit is the first installation of this size.

The 180 ton centrifugal water vapor refrigeration machine on the 58th floor. Left—Evaporator and other equipment on isolating base to prevent transmission of vibration to building steel. Center—The compressor and motor driven vacuum pump. Right—Close-up of the vibration isolating foundation



Left—Typical corridor in the offices, showing outlet in ceiling and louvred doors to offices. Right—Part of the air conditioned general office space

Condenser Water Cooling System

Cooling the condenser water for the refrigeration plant necessitated the use of a forced draft cooling unit of the air washer type within leased areas. A forced draft tower on the roof twelve floors above was prohibited. This air washer is 19 ft wide, 9 ft high, and 7 ft long, provided with entering and leaving eliminators and spray chamber.

A centrifugal fan with forward curved blades handling 80,000 cfm draws outside air through louvres in spandrel beams in the pipe gallery on the north side and then through the cooling tower air washer on the floor above, discharging the saturated air at approximately 83 F through louvres in spandrel beams in pipe gallery on the south side. The water is distributed over the air washer area by two banks of mist type non-clogging spray nozzles.

Vibrationless Base for Refrigeration Machine

It is well known that mechanical vibrations once transmitted to building steel will carry some distance with strange results. Forty floors below the American Cyanamid offices is a large broadcasting studio and one floor below is a telephone exchange. Thus, it was essential to mount the refrigeration machine on a vibrationless base to isolate it entirely from the building steel.

After a thorough study, tempered steel springs were used, arranged in pairs with alternate pairs at 90 deg angles and designed so as to be under maximum tension. The supporting steel was designed so as to transmit the loads to the four columns equally and to stay within allowances of the building column steel design. This method of mounting is known as a floating base and thus all rigid pipe connections to the refrigeration machine were provided with reinforced rubber flexible joints.

The results have exceeded expectations. No vibration nor noise is transmitted to the building steel or adjacent areas; in fact it is possible to balance a nickel edgewise on the base when the refrigeration machine is in operation.

Automatic Control of Temperature and Humidity

The system was designed to maintain in the summer, an inside dry bulb temperature of 80 F with 50 per cent relative humidity when the outside dry bulb temperature is 95 F and the outside wet bulb temperature 75 F. In the winter it will maintain an inside dry bulb temperature of 74 F and 30 per cent relative humidity when the outside dry bulb temperature is zero and when supplemented by direct radiation (which was already installed) to care for building transmission losses.

As mentioned, each booster system was designed to condition each exposure on each floor, simplifying the automatic control requirements to meet the changing solar heat load.

Control of the systems is obtained electrically by means of electric thermostats, electric steam valves, electric damper motors for controlling automatic dampers, transformers and electric switches. The principle is based on a potentiometer coil over which moves a blade actuated by a change in temperature, thus unbalancing the potentiometer circuit. This unbalance actuates a normally balanced solenoid relay, closing contacts which cause the motor which furnishes motion to operate a steam valve or lever arm for a control damper to operate. This motion is continued until the electric balance is restored, opening the relay and opening contacts; conversely, reverse motion is obtained.

There is no hunting or fluttering in this operation and therefore a full range of operation of a valve or damper may be obtained within 1 F range. The thermostats were therefore designed specially to increase this close temperature range to obtain graduated action over a wider temperature range.

Fresh air dampers are operated by an electric solenoid switch wired in the primary fan motor circuit and opening when the motor is started. These dampers were designed with extra strong blades and felt strips to withstand the wind pressure of a 60 mile gale.

Humidity is controlled by an electric thermostat immersed in the water in the dehumidifier tank. This thermostat is actuated by the water temperature, which is the dewpoint temperature of the saturated air leaving the dehumidifier. In the summer, this thermostat operates the fresh air dampers to minimum position with maximum outside wet bulb temperature. In the winter, this thermostat operates the fresh air heaters to maintain a constant dewpoint temperature leaving the air washer or humidifier.

The nine booster fan controls are similar. A dry bulb thermostat located in the return air bypass duct controls the chilled air supply damper operating on a falling room temperature to throttle the chilled air. An additional duct type thermostat in the fan discharge for winter control operates the booster heaters delivering the air to the conditioned areas slightly below room temperatures. Direct radiation makes up the marginal heat requirements.

The executive offices have special volume control actuated by a wall type thermostat in each room.

Operating Costs and Data

All the air conditioning equipment is situated in interior spaces of little value and in pipe gallery space. The floor area or space required for air conditioning equipment is but 3.3 per cent of the total leased area.

Although this system is designed for year-around service, complete winter records are not yet available. In estimating the cost for complete air conditioning, no allowance is made for comparison with a ventilation system, which would have been required if air conditioning had not been installed.

The total investment cost based on a 5 per cent interest rate and yearly operating costs (power, water, steam, maintenance and labor, winter-steam and power approximated), was 28.6c per sq ft per year. When the architectural and structural changes required to accommodate an air conditioning system at such a great height are considered, it is not surprising that 40 per cent of the 28.6c per sq ft cost is chargeable to construction, electrical, plumbing, and heating changes involved.

Another interesting comparison is the ratio of installed motor power load to total leased areas, which equals 3.4 motor hp per 1000 sq ft. The power rate is approximately 4c per kw-hr. The water requirement is 0.1 gpm due to evaporation in the condenser water cooler; thus the cost of water is negligible.

You will remember that 180 tons refrigeration was installed using a 150 hp motor. This is a ratio of 0.83 hp per ton installed horsepower load. Under maximum conditions, tests showed that with 85 F condenser water temperature, this installation developed 192.5 tons refrigeration at 153 brake hp, or a ratio of 0.79 hp per ton.

Comfort, Health and Personal Efficiency

Air conditioning of office spaces is beneficial in many ways—clean pure air, ideal healthful conditions summer and winter; with windows kept closed, the noises from the street are shut out. However, the tangible returns to warrant the investment for air conditioning offices are not so easily measured in dollars and cents as in a theater, restaurant or department store. Office managers and executive officers of large companies who have experienced air conditioning readily admit air conditioning pays but comparative cost figures are lacking.

However, there is a measuring yardstick which gives a method for comparison for air conditioning in office spaces. This is by dividing the yearly cost of the investment by the total number of hours worked by all employees per year. On this basis, the cost of air conditioning per person amounts to two cents per person per hour or sixteen cents per person per day for an eight hour day.

Use of Superheated Steam in Radiators

CAN you give us any references on the subject of using superheated steam in radiators and in heat exchangers, particularly on the probable effect on the steam consumption? —W. A. S.

Reply: The heat transfer from a bare pipe or radiator to the surrounding air depends only on the temperature difference between the outside surface and the air, the temperature of the air, and the nature and shape of the surface. In the case of saturated steam, the drop in temperature from the steam to the air is only a fraction of a degree, but in the case of superheated steam this drop in temperature may be anywhere from 3 to 50 F or more, depending on conditions of flow. Hence, for a given steam temperature the heat transfer will be less with superheated steam than with saturated steam. This probably will not affect the economy or the steam consumption, but it will make necessary the use of a greater amount of heating surface in order to transfer a given amount of heat.

Prof. R. C. Carpenter, in a paper entitled "Tests of Radiators with Superheated Steam," *Trans. A.S.H.V.E.*, Vol. 7, 1901, pp. 206-216, gives some data on two radiators. With steam at a pressure of 2.0 lb per sq in. and 36 degrees of superheat, the coefficient of heat transfer was reduced from 1.48 to 1.16, and from 1.83 to 1.41 Btu per sq ft per deg per hr respectively for the two radiators. This represents a reduction of approximately 22 per cent, or 0.61 per cent per degree of superheat.

With steam at 5 lb per sq in. pressure and 13.1 F superheat the coefficients of heat transfer were 1.41 for the low radiator and 1.74 for the high one. Increasing the superheat to 24.1 F reduced the coefficients to 1.23 and 1.41 Btu per sq ft per deg per hr respectively. This represents reductions of 12.7 and 16.7 per cent, or of 1.15 and 1.52 per cent per degree of superheat.

In commenting on these results, Professor Carpenter states that "the results indicate that it is poor practice to employ superheated steam for heating purposes, the reason doubtless being due to the fact that superheated steam is much more nearly like a perfect gas in its nature than a saturated vapor, and when in this condition parts with its heat much less readily than saturated or wet steam. It is not probable that the amount of superheat was sufficient in any of the cases described to fill the entire radiator with steam of this character, and this, I take it, accounts for the continued falling off in heat transmission as the degrees of superheat increased."

With steam at a given pressure it is probably possible to increase the degrees of superheat, and hence the temperature of the steam, until the temperature of the outside surface of the radiator becomes the same as that resulting from the use of saturated steam. In this case the coefficient of heat transfer would become the same for both the saturated and superheated steam, and the same amount of surface would be required to transmit a given amount of heat. Further increase of superheat would make it possible to use less surface with superheated than with saturated steam. The amount of superheat required to do this is problematical, and would probably depend on the configuration of the surface and the velocity of steam through the tubes.—A. P. KRATZ.*

*Research Professor, Dept. of Mechanical Engineering, University of Illinois, Urbana.

Design and Erection of a Bulk Fuel Oil Storage Plant †

By **Kalman Steiner***

● Pumps and piping must be a flexible system . . . Determining proper pipe sizes . . . Design of heating coils for oil tanks.

THE pumps and piping in a bulk fuel oil storage plant must be designed as a flexible system, for they must serve numerous purposes. An illustration with the first part of this article[1] showed that the following pumping operations must be and can be accomplished in the plant under discussion through a single battery of pumps and a valve nest with header:

1. Fuel oil can be unloaded through the bottom car connection and pumped into any of six bulk tanks, or any of three work tanks.
2. Fuel oil can be pumped from any of six bulk tanks or three work tanks up to either of two truck loading racks.
3. Fuel oil can be pumped from any one of nine tanks into any of the other eight tanks.
4. Fuel oil can be pumped from any of the nine tanks up into the cars on railroad siding.
5. It is possible to handle six grades of oil and to keep them segregated in handling by confining any two grades to a single piping and pumping system. This avoids mixing of liquids or contamination in the lines when operations are switched from one grade to another.
6. It is possible to unload four tank cars simultaneously, handling either one, two, or three different materials.
7. It is possible to load four trucks simultaneously, handling from one to four different materials.
8. Gasoline is handled by a completely separate set of equipment, from tank cars into tanks, and from tanks into trucks.

There are two twin oil pumping units—one for heavy oils, driven by a 15 hp motor, and one for light oils powered by a 7½ hp motor. Each consists of two 200 gpm rotary gear pumps. Relief valves on the discharge connections are set for 50 lb. Motor starters are equipped with push-button stations in multiple, so that they may be operated from several points in the pump house or from either of the two loading racks. The gasoline pump also handles 200 gpm, but is a single unit driven by a 5 hp motor.

The track siding is long enough to hold eight tank cars. Unloading connections and steam connections are placed so that each set of valves can be connected to the two cars immediately adjoining that location by flexible hose. The cars are steamed in cold weather to facilitate unloading. The condensate from the tank cars is wasted, since it would be difficult to collect and would pick up considerable oil while passing through the car coils and connections.

Fig. 1—The track siding

Two sizes of piping are used throughout the plant for conveying fuel oil. Three inch piping is used for lighter grades (Nos. 1, 2 and 3) and 4 in. for the heavier— Nos. 4, 5 and 6. The pressure drop through a 4 in. line working under the worst likely condition—the pumping of No. 6 oil, which is the most viscous material handled in this type of plant—is calculated as follows:

The first step is to determine the velocity of flow, u, of fuel oil through the pipe line, from:

$$u = \frac{q/7.5}{60\,\pi\, d^2/4\times 144}$$

in which

q = flow in gpm
d = internal diameter of pipe, in.

In the case we are considering, $q = 200$ and $d = 4.03$, so that:

$u = 5.03$ feet per second.

It is now necessary to determine the friction factor, f, for the conditions of flow prevailing:

$$f = 0.00207\,\frac{Z}{Dus}$$

for which

Z = viscosity of oil in absolute units (poises)
D = diameter of pipe, in.
s = density of oil as ratio to water.

The value of Z is obtained from the Saybolt Universal viscosity in seconds, t, and s, by the relationship:

$Z = s\,(0.22t - 180/t) = 0.98\ \ (0.22\times 1500 — 180/1500) = 323$

Even the heaviest and most viscous No. 6 oil could be brought down to a Saybolt time of 1500 seconds, and this value together with a density of 0.98 gives the value of 323 for Z to be used in evaluating f. Hence:

$$f = 0.00207\,\frac{323}{4.03\times 5.03\times 0.98} = 0.034$$

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[1]See p. 241, H. P. & A. C., May, 1935.

This value of f can now be used in a modified form of Fanning's equation which will give the pressure loss in a length equivalent of pipe L,

$$p = \frac{4fSLu^2}{2gD}$$

where

p = pressure drop, lb per sq *ft*
S = specific gravity of oil, lb per cu ft
g = acceleration due to gravity, or 32.2 ft per sec per sec
D = diameter of pipe, ft
L = length of straight pipe, ft, plus equivalent length due to bends, etc.
u and f as above.

The longest run in this system of piping, augmented by additions for bends and loss through pump header, valves and pump itself, is about 165 ft. The weight of fluid is 61.25 lb per cu ft. Substituting:

$$p = \frac{4\times0.035\times61.25\times165\times(5.03)^2}{64.4\times0.336}$$
$$= 1670 \text{ lb per sq ft}$$
$$= 11.7 \text{ lb per sq in.}$$

With a maximum pumping head of 50 lb available, the possible loss of 12 lb through the pipe line under the worst conditions is not excessive and leaves some 38 lb pressure available for overcoming static head when pumping against the liquid head in the tank, which is ample. Hence the choice of 4 in. pipe.

It is almost obvious that if 4 in. pipe is sufficient for a heavy oil running up to 1500 Saybolt viscosity that a 3 in. is ample for the lighter oils, for these viscosities seldom exceed 75 seconds Saybolt Universal.

Heating the Storage Tanks

It is apparent that the tanks holding the heavier oils must have adequate facilities for maintaining the oil temperature sufficiently high so that pumping will be possible, regardless of atmospheric temperatures. The lighter oils can be pumped at almost all ordinary temperatures, but there is also need to provide heating of this material because of the loss in volume, or contraction, if the oil is permitted to fall considerably in temperature.

Again, if the design of a heating coil for the most difficult conditions (heating of No. 6 oil in bulk storage) is analyzed, it will serve to illustrate the method and application of principles. For this purpose we turn to that one of the six main tanks which is intended for the storage of No. 6 oil.

While in general the laws of heat transfer which govern the processes of heating liquids with steam apply, it must be borne in mind that because of the vast difference in viscosity of the material heated, as contrasted to water or other free flowing liquids, modification of these laws must be made. The phenomenon of convection, for example, is entirely different for a viscous oil than for water. This means that a particle of fluid, upon being heated, instead of rising and being replaced at the heating surface by a cooler particle, tends to remain in contact with the heating surface for a length of time. Hence, a certain amount of heating is accomplished by conduction of heat from the metal surface through the surrounding oil. Clearly, then, the transfer of heat from steam to the oil is a slow process.

Authorities differ as to the correct coefficient of heat transfer under these conditions; values ranging from 5 to 40 Btu per sq ft of surface per hr per degree temperature difference have been stated. With a wholesome respect for the viscosity of No. 6 oil when atmospheric temperatures are at the zero mark or less, the use of a coefficient of 10 is not too conservative. This much is certain, that if the designer is anxious to hold down equipment costs, he could not choose a more delicate or dangerous variable on which to take a chance than in choosing a coefficient of heat transfer for highly viscous oils.

For reasons stated below, the steam plant under consideration was constructed for conversion to high pressure if later it should be so desired, but at the outset operation is with low pressure steam. This establishes the steam temperature at about 215 F. The maximum required oil temperature is 150 F. Therefore, under the worst conditions, the initial temperature difference, or D_1 at 10 F below zero would be 225 F. Actually, it is not necessary to design for this extreme condition, because the fuel oil is always heated in the cars before being unloaded, and so will be at approximately 90 F when entering the tank. This reduces the temperature difference, or D_1, to 125. The contingency of oil in storage cooling to extreme atmospheric temperature is very unlikely, for in the event of a boiler shutdown, for example, the very viscosity which makes oil slow in heating will also make it slow in cooling—that is, the outer layers in contact with the tank walls will act as insulating layers keeping the hot oil of the tank's interior protected from this radiating surface at the walls. It is therefore quite safe to assume a value of D_1 at 125.

The minimum temperature difference, D_2, will of course be 215 — 150, or 65. The mean logarithmic temperature difference is evaluated from:—

$$D = \frac{D_1 - D_2}{2.3 \times \log (D_1/D_2)}$$

whence $D = 129$

In other words, there will be transmitted from the steam to the oil an average of 1290 Btu per sq ft of surface per hr. It remains to determine how many heat units per hour will be required, so that the needed surface will be known. Assuming that the bulk tank of 100,000 gallons is emptied and refilled once daily, then the average quantity of oil heated hourly is about 4200 gallons, or 34,146 lb. Since the temperature rise is from 90 to 150 F, or 60, and the specific heat of fuel oil is 0.5, then the total heat required per hour is $34,146\times60\times0.5 = 1,024,380$ Btu. Dividing this total by 1290 gives a total required heating surface of 794 sq ft.

Before passing to a discussion of the coil construction for embodying this surface, a few comments should be made on other theoretical considerations. The coefficient of heat transfer which was used above, 10, represents static conditions, that is, a quiet liquid body, without motion except for the convection currents set up by the heat itself. But when a kinetic condition prevails, as when oil is in motion through a pipe line or even over a coil surface, then the coefficient increases greatly. For example, when the pumps are pulling oil out of storage at the rate of 200 gpm, the velocity of the oil over the

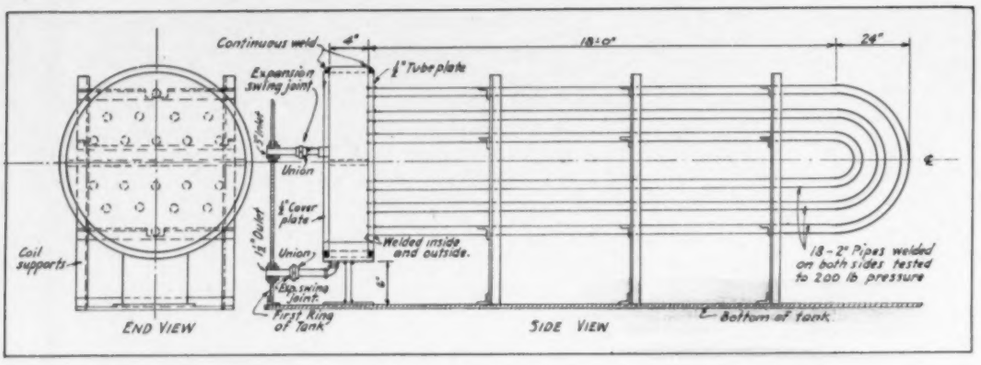

Fig. 2—Construction details of tank heating coils

coil surfaces may accelerate the heat transfer rate to as high as 50 Btu, and at such times the coils will act as instantaneous heaters, actually raising the oil temperature through its full range while the oil is in transit over the coils. This fact influences the spacing of the coils, as will be seen below. Or again, it will be remembered that the discussion of heating surface required was based upon heavy No. 6 oil. In the lighter oils viscosities are so much less that convection currents are readily set up.

Two coils of 265 sq ft each were provided in the tanks for oil Nos. 1, 2, 3 and 4, while three such coils were installed in the No. 5 and 6 tanks.

Fig. 2 shows construction details of the heating coils, which are built up of 2 in. steel tubing welded into long U's. Laid horizontally, the upper ends of the coils are bundled together into a steam header, the lower ends into a condensate header. Note that the open end of the U is wider than the turned end. The coils are set with the center line of the U exactly horizontal. There is, therefore, a pitch of the upper leg of the U toward the turned end, and a pitch of the lower leg toward the open end or condensate header. This keeps the water on a gentle slope throughout the entire coil, and water pockets and water hammer are avoided.

In the first four tanks, which have each two sets of coils, one set is placed on each half of the tank bottom. In the other two, three sets are provided, and an equal spacing over the tank area is accomplished. This arrangement brings the maximum amount of oil over the coil surfaces as the liquid is pumped into and again out of the tank. In this way the coefficient of heat transfer is maintained at a maximum.

Because of this last consideration, the coils for the work tanks need not be designed on so conservative a basis as these for the bulk storage tanks. In these smaller units the oil is in motion a great deal of the time, and it also enters at a temperature much higher than the oil entering storage from the railroad cars. Therefore these tanks can be provided each with a single 265 sq ft coil.

The steam and condensate piping for the coils is provided with ample space for expansion, as well as angles and turns to absorb expansion and contraction stresses. Since all the piping was welded, it was very easy to weld up all the joints of the steam and return piping inside the tanks; this was done in all cases with the exception of a single screwed union on each steam and return connection. These were used in preference to a flanged union as the gasket of a flanged joint cannot readily be made entirely proof against fuel oil, which always contains some sulphur.

It was mentioned that this plant was placed in operation with low pressure steam. As a matter of fact, however, the entire heating system, from boiler back through the returns, has been erected as a high pressure system, and could be converted to such operation by a few simple changes. While it is true that a high pressure steam system has its advantages for applications such as a bulk storage plant, the low pressure scheme offers these inducements: A licensed stationary engineer is not required, boiler room attention is reduced to a minimum, and steam for heating of buildings is available directly from the mains without the necessity for pressure reducing valves. Against this, a high pressure plant would give higher steam temperatures and so minimize the coil surface required for tank heating—a factor not to be lightly dismissed—and smaller pipe sizes could be used. There is another phase to this comparison of high pressure versus low pressure, which will appear later under the discussion of electric power.

[The third and last part of this article covers estimation of boiler capacity, steam and return piping, heating plant offices, and future generation of electric power.—EDITOR.]

The "kitchen door" in service on the Burlington Zephyr, one of the twin streamlined trains running between Chicago and St. Paul, is not a door at all but a moving curtain of air occupying the opening between the kitchen and eating space. The air curtain offers unobstructed vision and free passage at all times, but keeps cooking odors and heat away from passengers who are being served. This sheet of air is forced through a small slit in both sides of the door frame, directed toward the center and deflected slightly toward the kitchen. Immediately overhead on the kitchen side is an exhaust ventilator, so that fumes checked by the air curtain are picked up by the fan and blown outside the car.

The forced draft of air is one of the features of the complete air conditioning of the Zephyr. Capacity of the refrigerating system is 5½ tons per car, which is considered ample because of the double glazed windows and the heat reflecting properties of the stainless steel exterior of the train. In moderately cold weather, overhead coils will keep the compartments comfortably warm without sidewall radiation.—W. T. Cook, General Electric Co.

CHECK Plant and Building Heating

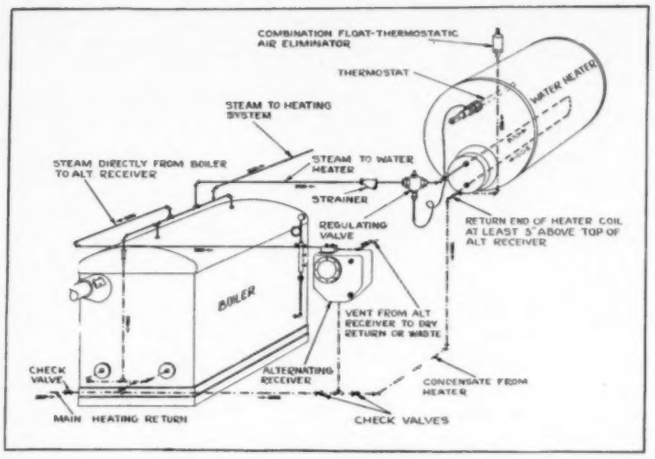

Fig. 1—Method of returning condensate from water heater coil to boiler through alternating receiver.

By **T. Napier Adlam***

BECAUSE the end of the heating season is the proper time to review the heating troubles and inefficiencies of the past winter and take the proper steps to correct them, the object of this article is to suggest some of the points a "heating system review" should include. Each plant and building has its own particular problems, of course, so that any general discussion can hardly be expected to cover the entire subject. An article in the April 1935 H. P. & A. C., included a number of suggestions which are supplemented here.

Vacuum Pump—Vacuum pumps should receive proper attention as soon as the heating season is over. A faulty pump can waste 10 per cent of the steam, and a faulty pump or leaky joints in the return line will increase the power consumption of the pump motor.

A thermometer in the main return pipe close to the pump or on the pump itself is advisable. If the pump fails to retain the vacuum correctly, and the return is not too hot, it can be safely assumed there is air leakage in the pump or in the return line. If the temperature is too high and the vacuum is not retained, then the steam traps should receive close inspection.

Boiler Return Traps—Heating systems which have boiler return traps instead of vacuum pumps should receive equal attention at the end of the heating season. The cover of the return trap should be removed and the inside cleaned thoroughly. The steam and exhaust valves of the return trap should be inspected and cleaned, and the return water check valves on each side of the return trap should be examined. Steam is wasted and trouble caused by dirty check valves, etc., and often hot water and steam is discharged and heat wasted.

Domestic Hot Water—Large savings in connection with heating the water for domestic use frequently can be made; and since this is a year 'round proposition it should receive very careful consideration.

If there are no temperature regulators to close off the steam, it pays to install one on each tank; due care should be taken to insure that the bulb of the regulator is in the correct position. Many installations are ineffective because the bulb is in the wrong place (see Fig. 1).

Regulators should be examined every six months, when the valves should be taken apart and washed with kerosene. A sticky valve is a source of waste, while grit or scale in the valve will soon wear away the surfaces and cause it to leak long before it should; furthermore a dirty valve places a strain on the thermostat which will destroy its life. Working parts of the regulator or valve should be oiled at least every three months.

A temperature recorder on each tank gives warning if the temperature has not been maintained, or shows if the valve leaks and allows the temperature to go too high.

Another hint for improving hot water conditions is to install a boiler return trap on the condensate return from the steam coils in tanks. The installation shown in Fig. 1, which had gravity return to the boiler and previously took 2½ hours to heat up the water in the morning, took only 30 minutes to heat to the same temperature after installing a boiler return trap; the installation was paid for in one year out of savings, due to the shorter period required for heating up in the morning and because the temperature regulator can now be allowed to shut off the steam entirely when the temperature is sufficient, without flooding the steam coils with condensate.

The installation of a boiler return trap for a hot water tank coil where a pump is already installed for the combined service of heating and hot water coil, will save electricity during the summer and four or five months wear and tear on the pump each year.

Blended Water—Usually a temperature of 130 to 140 F on the tank will be ample, but where the water is to be used for laundry or other purposes where the temperature must be higher than this, a saving can be made by installing a blender on the lower temperature supply. This not only saves overheating on the bath and lavatory fixtures; it also enables a larger quantity

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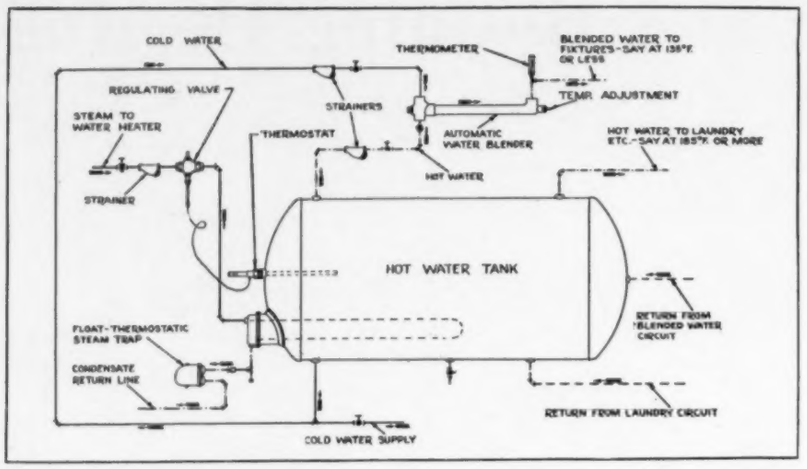


Fig. 2—Arrangement for supplying hot water at different temperatures for different purposes

of water to be drawn off. If a tank has a storage of, say, 1,000 gallons of water at 185 F this would give a blended supply of approximately 1,600 gallons at 130 F, an advantage where the storage capacity is relatively small for any kind of installation. It is advisable to have thermostatic valve control on both hot and cold, and compensate for varying water pressures (Fig. 2).

Drying—Many apartment buildings have laundries and kitchens where sizeable savings can be effected with practically very little outlay, but to deal with all these possibilities is beyond the scope of this article. With drying rooms or cabinets it is possible to improve the drying effect considerably by installing a small fan inside the chamber to agitate the air and circulate it among the hanging garments. This will often cut down the time of drying by more than half, and save considerable time and heat. Also, in connection with larger drying chambers, a small fan to extract the moist air will often do more good than applying extra steam coils, and at considerably less cost and a saving in steam.

Control of Heating System—Better control of the heating system in relation to weather conditions is one of the best methods of improving next winter's operation of plant and building heating systems. The benefits are economy in fuel consumption, greater comfort, and less supervision required. Owners sometimes look solely to the financial aspect, without due regard to the comfort and supervision factors, which are more difficult to evaluate in dollars and cents.

An extremely comprehensive discussion would be required to cover the several methods of heating system control which are available, and the advantages and disadvantages of each. A number of articles published in H.P.&A.C. have described the fuel savings and other advantages of specific types of control in typical plants and buildings; for more information on the subject, the reader is referred to these.

It is the author's belief that the trend is toward systems controlled more closely according to outside conditions. Internal "key room" control may be satisfactory if the building offers uniform exposure both inside and outside, but there are few buildings with several hundred rooms where one room can be found that will give an average condition; still less is it likely to find any one occupant's requirements the average of all the rest. Only the slightest heat left in the radiator will often satisfy most occupants, but immediately all heat rays are shut off a chilly feeling is experienced even though the temperature of the air is within the comfort range. A system that might prove satisfactory with cast iron radiators will not always be so where concealed heaters are installed.

Vacuum Tube Sounds Warning if Freezing Threatens Piping

***By* Francis A. Westbrook**

THE illustration shows a heat control unit used in connection with an alarm to avoid freezing of a sprinkler system. It is located in the attic of one of the buildings of the Gotham Silk Hosiery Co., Dover, N. J.

This vacuum tube unit operates a horn if the sprinkler piping is in danger of freezing

The unit (one of six) consists of a small vacuum tube with electrodes which act as a relay to close an electrical circuit which operates an electric horn in the boiler room by means of a storage battery in the circuit. It is designed to operate at 38 F and is taped to the sprinkler pipe, with the terminals connected across the open wire circuit as shown. When the temperature of the sprinkler line drops to 38 F, the relay closes the circuit and the horn gives the warning.

Protection of this kind is particularly necessary not only because of the usual damage which would result from water, but also because of the susceptibility of the silk materials to damage, as well as to the fact that the sprinkler system becomes inoperative when frozen.

CHOOSING *the right* AIR CONDITIONING SYSTEM

Part 5—Fundamental Considerations

By **A. Warren Canney***

IN PART 4, the fundamental considerations in the choice of a unit or central type air conditioning system were summarized, and the extension of summer air conditioning to year 'round operation was discussed. It was pointed out that the real basis for the use or non-use of ducts is air distribution.

If the use of ducts is indicated, together with operation of the system during spring and fall, then it next must be determined whether the system may be completely shut down or kept running during the hours that the heat gain to the conditioned space is, say, less than half during the maximum possible number of operating hours. For example, on small installations particularly, the tendency is not to use cooling equipment during early and late summer. But to assure proper conditions or where the interior heat load represents a large part of the total heat load, the system must often be operated during these times of the year.

If a comparatively high percentage of usage is indicated, together with a high total heat load with a low ratio of latent to total heat, then evaporative cooling with a recirculated water spray enabling shut down of the refrigeration during those hours is warranted. This is where the economy of sprays comes in. Reheating or volume control or both become essential for the intermediate seasons and usually so for many days during the summer. Volume control may apply to the air quantity through the conditioning apparatus, or the total air delivered, and not infrequently, to both.

Direct Expansion, Cold Water Coils, and Sprays

Here we have the problem of control. But another also comes up for decision: Shall (a) direct expansion be used, or chilled water be either (b) sprayed directly or (c) circulated through coils?

This is really a matter about which no one can make generalized recommendations. This much can be said, however: If there are several conditioning units to be served on which the refrigeration demand will be "out of step," chilled water may be considered. If as a general thing the system is to function more than seven months of the year, a water spray alone may be indicated. But a monthly basis is not the true comparative basis. The investment set-up should be predicated on an hourly analysis, including all operating hours of the proposed system. Whether a thousand dollar or a million dollar system, the right choice compels such an analysis translated into initial and operating costs.

Another major question which arises is the subdivision of that apparatus which processes or conditions the air.

On virtually every air conditioning installation for summer operation, the air delivered must not only absorb heat but water vapor.

The air with its absorbed vapor and heat can be thrown outdoors or partially re-conditioned, whence latent heat removal (dehumidifying) becomes essential as well as cooling. Without going into the full technical explanation, suffice it to say that the condition of the air entering the space is entirely independent of the volume delivered if a saturated supply is used as with a spray type dehumidifier, with or without recirculation bypassing the sprays. The volume of saturated air per minute depends solely on the maximum load. But with a conditioner—as with coils—that does not saturate the air, this ratio of the heat loads and the air volume delivered are interdependent.

Under such conditions the dewpoint temperature of the (saturated) supply is contingent only on the relation between the total latent heat of the vapor emitted and sensible heat emissions, best expressed as

$$\frac{H_L}{H_S+H_L} = \frac{H_L}{H_T}$$

where H_L = total latent heat to be absorbed
H_S = total sensible heat to be absorbed
H_T = total heat to be absorbed = H_L+H_S

Where the latent heat absorption by the delivered air is zero, the sensible heat is the total heat and the delivered air undergoes only a heating up process. This however is seldom the case in summer as the vapor from infiltration, people or both, usually requires absorption by the air. It is not sufficient to design for this maximum ratio. Controls must consider its variation in the same or in different spaces.

In theaters and luncheonettes, for example, this ratio runs fairly high, sometimes 0.35 to 0.4.

This depresses the temperature of the saturated supply considerably below the room dewpoint, and, with a given volume of air through the conditioner, an unsaturated supply. This is important, as this establishes the lowest thermal level at which the refrigeration machine must operate, and, with sprays, at the point of maximum refrigeration load.

But with metallic coils the whole thing becomes complicated; in this case the significant point to remember is that with metallic coils the ratio of latent to total effective heat extractions becomes less as the mean tem-

*Engineer in charge of air conditioning, Clyde R. Place, Consulting Engineers, New York, N. Y.

perature difference between the entering air and the refrigerant becomes less so that careful investigation of lowest entering temperature and simultaneous relative humidity is necessary with respect to the ratio characteristic required of the coils in relation to the room load prevailing at these lower entering air conditions.

Coordination of Control

If the spaces to be conditioned have, in summer (or winter or any other time, dependent on the seasonal scope of the system) one or more of the following conditions (which largely comprise the basic technique of air conditioning engineering):

(a) total loads that vary independently at different times;
(b) loads which have ratios of H_L/H_T which vary independently;
(c) different system thermal characteristics;
(d) different rates of change of total loads or ratios of loading;
(e) require different atmospheric conditions;

then subdivision of apparatus and in any case coordinated control comes up for analysis and design considerations. It is not generally supposed—but it is a fact—that these five factors play a very considerable role in careful air conditioning design practice; any air conditioning apparatus in which design and control are not coordinated is not worthy to be termed a "system."

Where widely different ratios are demanded, either instantaneously or as to rate of change, the conditioning apparatus should be split accordingly.

Where the matter of this ratio is involved, or merely different total loads, the volume of conditioned air delivered (excluding any recirculated) must be varied, or the temperature of discharge varied by after-heating or by both, to the same or to the individual spaces served.

These considerations will in the main govern the subdivision of apparatus and controls. After that, subdivision or non-subdivision becomes a matter of money and physical coordination.

Outdoor Air Volume

Another issue is the correlation of outdoor air supply and exhaust to the atmosphere so that infiltration and exfiltration of air to and from the spaces conditioned may be "pegged" so that definite values can be chargeable to these for the ultimate determination of refrigeration, fan resistance, pressure, air pressure, air preheating, reheating and (winter) heating capacities, while at the same time, providing assurance that the volume of outdoor air intended to be supplied will, in fact, be secured.

After establishing the amount of outdoor air required, it becomes essential to make certain that this volume will actually enter and therefore actually leave the spaces conditioned, and that fluctuating barometric pressures surrounding the space will neither tamper with this volume nor increase the air leakage inward or outward from the values assigned. This is a most uncertain item, partly because engineers who are in the business of making people comfortable are still trying to overcome unscientific building construction (from the comfort angle) and because there is less scientific experience prevailing in this matter than in other phases of air conditioning work.

When the installation requires ductwork, and when the advantages of evaporative cooling can be utilized and if subdivision of apparatus is indicated, together with other auxiliaries for control, then we begin to have a picture of what any small, or large, or simple, or diversified space needs for proper year 'round air conditioning.

Having roughed up the general aspects of the equipment to this point, it then becomes timely to consider the matter of winter humidification requirements and control; and also, the correlation or functioning of the equipment with respect to heating. When we started with the summer approach exclusively, we took a long route before we arrived at the heating season problem.

Variations of Conventional Methods

In passing it might be mentioned that there are several sundry modifications of the normal set-up such as flooding direct expansion coils, or running condenser water through an air precooler and thence to the condenser, or reheating with the leaving condenser water, or bypassing the conditioner with outdoor air. Unless automatic controls are added to a corresponding degree the economic value of such modifications becomes doubtful. Then, too, a system frequently becomes complex enough without employing tricks which require the best of automatic control to show an investment advantage.

If, for example, a low dewpoint is required it is wise to flood the direct expansion coils with a spray from a tank of ample capacity to avoid frosting on the coils and resultant inefficiency. The matter of evaporative cooling is a separate item from the flooding requirements just mentioned, although the same spray, if evaporative cooling is to be incorporated, can act as a coil flooder.

As for recirculation which bypasses the spray, the advantage of so doing is considerable if a constant volume of outdoor air is desired with constant volume of delivered air for distribution.

Recirculation for bypassing the conditioning apparatus is patented. Aside from questions of relative economics, dependent on the set-up you wish to compare it with, it fulfills two simple and valuable functions: It permits the variable control of capacity by varying the amount of air through the conditioning apparatus above the minimum and, dependent on the additional relative volume recirculated, predetermines the minimum and maximum temperatures of the air delivered for either heat absorption or heat addition to the conditioned spaces.

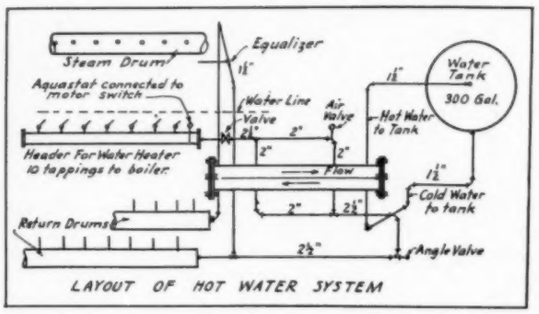
The minimum delivery temperature permissible from the outlets together with the volume of air to be varied through the conditioner for control are very important factors, as correlated with the dewpoints of the air leaving the conditioner at minimum and maximum ratios of latent to total heat loads as well as minimum and maximum total loads. Since the essence of air conditioning is control, numerous other advantages accrue from bypassing, and while not always essential, competent engineers should be the judges.

To Keep a Temperature at Any Point

By **Samuel R. Lewis***

Put the Control Where the Temperature's Wanted

Question: The heating plant for an apartment building consists of a sectional boiler with a hot water heater connected as shown in the sketch. The thermostat controlling the oil burner is in the hallway of one of the apartments and cuts off at 75 F.



LAYOUT OF HOT WATER SYSTEM

Operation is satisfactory in cold weather, but in mild weather when the thermostat takes control, circulation from the boiler through the water heater stops and the service water is cold. How can this be corrected?—F. W.

REPLY: It appears from the sketch that the boiler and water heater piping all is satisfactory. The thermostat upstairs controls the oil burner in winter and calls for steam to be generated, so that the boiler water is hot enough to warm the water in the service hot water tank.

There is shown an auxiliary aquastat in the hot water flow header where the hot water, emerging from the boiler on its way to the transfer heater, must pass. Presumably in summer there is a manually operated switch which cuts out the upstairs thermostat or this thermostat and the aquastat are in parallel so that either one may stop and start the oil burner.

The trouble lies in the location of the aquastat. When the weather is warm and no steam is needed, so that the upstairs thermostat resigns in favor of the aquastat, the aquastat starts the oil burner and very quickly warm water flows out of the boiler and reaches the aquastat on the boiler header first, long before it can reach the transfer heater or the storage tank, and of course the aquastat, responding, tells the oil burner to stop.

Hot water in the storage tank, rather than only in the boiler header, is what is wanted in summer. Therefore the aquastat should be placed in the middle of the side of the tank and it will keep the oil burner running in summer or in winter until there is plenty of hot water at whatever temperature is desired.

In winter, if the thermostat upstairs and the aquastat in the tank are wired in parallel, there might be occasions when the aquastat would keep the building a trifle too warm, but ordinarily there is no trouble on this score since the building heating demand usually exceeds the water heating demand. The remedy to such a situation would be to install a heat transfer heater of larger size. Manually operated switches on the wiring to the aquastat and to the thermostat whereby either one could be cut out easily, probably would lead to trouble due to forgetting to close one or the other of them after having opened it in some emergency.

Do not permit the aquastat to be placed in the transfer heater or in the pipes leading from the transfer heater to the tank.

There is nothing new or unique about the difficulty that has been experienced. Remember that if some temperature somewhere is desired, it can best be achieved by placing the heat-sensitive instrument right there and nowhere else.

*Consulting Engineer, Chicago, Ill. Member of Board of Consulting and Contributing Editors.

Repair and Test Room—

[*Continued from page 276*]

door forced draft cooling tower, the necessary auxiliary pumps, and the duct system. Although the total cooling load in the room amounts to approximately 25 tons, the large capacity compressor was installed to meet future requirements. It is operated by a two speed motor having a rating of 25 and 50 hp, the speed of the motor being automatically controlled by a thermostat in the washer pan actuated by the spray water temperature. Capacity can be further varied by manual setting of the compressor valves.

The instrument room, isolated from the rest of the building by partition walls containing a large amount of glass, is approximately 100 ft long, 34 ft wide, and 15 ft high. All of the air conditioning equipment is located within the room itself, the compressors and auxiliary pumps on the floor and the filters, spray, and blower above the buffing room. The air is distributed through grilles in a duct which is located in the center and runs the entire length of the building.

Control of Indoor Conditions

Approximately 12,000 cfm of air is delivered to the room of which approximately 25 per cent is outdoor air. The room temperature is controlled by a thermostat in the return air chamber. When the return air temperature falls below the thermostat setting, a bypass damper opens and allows the air after passing through the filters to bypass the washer. When the air temperature is above the setting, the bypass damper is closed.

WHAT ABOUT STANDARDS FOR AIR CONDITIONING?

STANDARDS for air conditioning is a live topic, as was evidenced at the recent meeting of the Illinois chapter of the *A.S.H.V.E.* devoted to the subject which broke all attendance records, and at which was discussed the "Standards for Certified Air Conditioning for Comfort" published by the *Chicago Master Steamfitters' Association* and developed by a committee comprising representatives from the *C.M.S.F.A.*, consulting engineers division of the *Western Society of Engineers*, and the *Ventilating and Air Conditioning Contractors Association.*

A number of arguments are advanced for and against the standardization of air conditioning; some feel that the advantages of standardization may be outweighed in that it will tend to prevent development; others who favor standards are concerned about the proper organization for establishing them. Published here are the comments of several engineers and contractors who have given thought to the subject; these remarks are aimed to give a picture of the factors involved in standardizing air conditioning:

Says Samuel R. Lewis[1]—Experienced engineers and contractors may not need such standards, but the man who approaches the details of designing cooling systems only occasionally, is sure to be aided if he can learn quickly what acceptable practice assumes for design temperatures and humidities. Standards give him this information.

The day has passed when the determination of the adequacy of a heating system could be made merely by dividing the contents of the room by some slip-stick factor. It has been learned that the glass area, outside wall area, the wind, and other elements have something to do with it. Determining the capacity of cooling systems involves all of these and many more intricate computations. Slight errors in the assumed design unit values make astonishingly large changes in the installed capacity, cost of refrigeration and ducts, and power for operation. Therefore it is very helpful to the designer if he may check his memory by referring to accepted standards as to minimum allowances for heat transmission, sunshine, infiltration and the like.

The inexcusable and ludicrous variation in sizes of apparatus selected by various bidders on almost any recent cooling project evidences the need of standards for those inexorable values which all must encounter and overcome. The load must be carried no matter how effective each bidder may feel his apparatus to be. Standards give at least the nucleus toward a starting line from which the development of all competitive bids shall commence.

Within the past few days one of the largest manufacturers of small air conditioning apparatus refused to accept a guaranteed performance contract unless his idea of the required refrigerating tonnage, 25, should be adopted. His competitor, rather new in the field, insisted that a 15 ton rated capacity plant was as large as ever would be required. Such a situation indicates lack of uniformity in computations or assumption, since the general apparatus was the same, and is discouraging, since the spread is altogether too wide. The owner need not fear that certified air conditioning will increase the cost. Rather will it decrease it, since fair competition can be secured with all bidders on an equal basis as to design quantities. Neither need the owner be exercised concerning the statement that the contractor's guarantee should be responsible only for coordination of the capacities of the various apparatuses which go to make up a complete plant. If the contractor can find out, as assuredly he may, under the provisions of certified air conditioning, how these various apparatuses compare in what they can do with what the owner and the engineer hope they can do, the contractor easily, safely and at low cost for the risk, can make a blanket guarantee.

There is nothing either stated or implied in the standards to prevent the contractor from selling and the owner from purchasing a blanket guarantee. The standards give suggestive velocities and temperatures for entering air to a cooled room. They are not intended to limit invention and experiment and the limits set forth will be modified if experience demonstrates the safety of so doing.

According to Otto W. Armspach[2]—The use of the basic factors as set forth in the standards will result in much greater consistency in the capacities of equipment recommended by competing contractors. A policy to continue as we have in the past with no resemblance of agreement in engineering thought does not merit, nor will it receive, public approval.

The factors which, in large measure, determine the size of refrigeration equipment are outdoor wet and dry bulb temperatures, indoor dry bulb temperature and relative humidity, extent of air infiltration and the quantity of outdoor air taken into the system. Furthermore, experience has quite definitely established the proper value of each of these as well as the other factors and nothing can be gained by avoiding the standardized and common understanding of factors of this kind.

The present day prospective owner of an air conditioning system becomes confused and frequently loses interest with the scattered opinions regarding equipment required to accomplish specific results. What is the remedy? Obviously it can only lie in the acceptance of those engaged in the industry of a standardized basis for design.

Says M. G. Harbula[3]—I believe standards of some sort are necessary for guidance in any field where differences of opinion might exist, and the movement to set some air conditioning standards should be heartily commended by everyone in the industry. As Mr. Lewis explained during the meeting at which the standards were discussed, the present draft is "submitted to the industry in general for analysis and comment and it is naturally subject to revision." Certain definite changes are most necessary.

Standards cannot be termed or considered as such unless they represent a majority opinion of a committee that would represent a cross-section of the entire industry. Such a committee should, in my opinion, comprise a qualified member from each of the following: American Society of Heating and Ventilating Engineers, American Society of Refrigerating Engineers, American Medical Society, American Chemical Society, American Society of Mechanical Engineers, the technical society representing the acoustical field, Chicago Master Steam Fitters Association, Ventilating and Air Conditioning Contractors Association, the national association representing the plumbing and sanitary fields, the ventilation divisions of the boards of health of half dozen large cities, the various trade journals representing the industry, and other interested bodies. The committee should also include outstanding research engineers, pioneers in the air conditioning field, and consulting engineers.

No committee formed to establish standards should exclude the owner. After all, the industry is no industry unless the purchaser spends. There are enough large purchasers of air conditioning today to have developed individuals who know considerable about air conditioning both from a technical standpoint and particularly a practical standpoint. I would strongly recommend that owners be represented on this committee by several members selected by the committee from large purchasing groups.

This industry is not young. It grew to its present proportions because of the integrity and sound business policies of those who pioneered it. The opinion of such individuals or companies should be particularly helpful to determine if standards of any kind at this time will really help and advance air conditioning or retard it.

A close examination of the guides of the *A.S.H.V.E.* and *A.S.R.E.* discloses the fact that we already have certain standards for air conditioning. Would a new set of standards befuddle the industry or help it? What will stop the promulgation of standards in every locality by interested groups? Certainly whatever is done in this direction should be national in scope and character and contain the endorsement of a committee representing the country as a whole, not just one section of it.

Standards should, in my opinion, be general. In a field that is decidedly technical, they should not limit the qualified designing engineer. This would stifle or kill the kind of ingenuity that helped make air conditioning what it is today—America's youngest and perhaps one of its most potential industries. I refer to several possible controversial points; namely, stipulated temperatures and humidities indoors. Shall all the valuable work done at the Bureau of Mines in Pittsburgh and being done even today along this line be scrapped? Shall the amount of fresh air taken in from outside be definitely established whether a conditioned space is in the country or in a smoke-clouded city? Is it intended to limit designing ingenuity by prescribing maximum speeds for refrigerating compressors? Will it help the industry, if standards prescribe duct velocities, thus not only limiting designing ability, but also making air conditioning prohibitive in many cases where space is not available for ducts carrying air at low velocities? Shall we discard the valuable work done by acoustical engineers to minimize and eliminate noise? That is one reason for having a qualified acoustical engineer on the committee I am proposing.

Standards for air conditioning should be carefully studied and analyzed by a committee representing every branch of this industry before being made final. It is my personal belief that this industry will prosper in a greater, quicker and more sound manner if restrictions are kept to an absolute minimum.

[*Continued on page 95, back section*]

[1]Consulting Engineer. Member of the committee which developed the standards.

[2]Chief Engineer, Kroeschell Engrg. Co.

[3]M. G. Harbula and Associates, Consulting Air Conditioning Engineers.

Heating·Piping
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American Society of Heating and Ventilating Engineers JOURNAL SECTION

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The Dust Problem in Air Conditioning

By **F. B. Rowley*** ***(MEMBER)***

Minneapolis, Minn.

The funds for this investigation conducted at the Experimental Engineering Laboratories were provided by the Graduate School of the University of Minnesota, and the studies were carried on with special reference to methods of measuring dust and the rating of air cleaning devices.

OF THE various air conditions required for comfort and health, one of the most difficult to deal with in a scientific way has been that of impurities. This applies particularly to the solid material which floats in the air in small sized particles commonly known as dust. Dust is composed of mineral, vegetable, and animal matter, and comes from practically every activity which may cause the abrasion of materials such as earth, sand, ash, rubber, stone, wood, paper, etc. The particles find their way into the atmosphere through such channels as industrial processes, household work, smoke from chimneys, moving vehicles, or any other action which may agitate the air. Dust particles will remain in suspension for periods of time, depending upon their size, density, shape, and movement of the air. Some of the finer dust may remain in the air for years.

In order to deal intelligently with dust, it is best to consider some of its properties which may make it objectionable and which may possibly be used to indicate its presence or to remove it from the air. Some of the properties which might be considered are density, size and shape of particles, color, and chemical composition. For the purpose of this discussion, the size and number of particles in a given volume of air are the most important. However, other properties such as the tendency for small particles to aggregate into larger masses, will be considered. The effect on the human system is partly governed by the composition of the dust, and partly by the size of the particles.

Solid particles in the air are commonly classified, according to their diameters, as dust, fumes, and smoke. There is really no sharp line of demarcation between these classes. In general, dust ranges from the largest size particles which rapidly settle out of the air down to particles 1 micron in diameter. Fumes range from 1 to 0.1 micron, and smoke from 0.3 to 0.001 micron. (1 micron = 0.0004 in.) It is estimated that particles above 10 microns in diameter do not enter the human lungs and that particles below 0.5 micron in diameter will not be retained in them. It is therefore evident that, insofar as damage to the lungs is concerned, only particles which are less than 10 microns in diameter are of interest. It is generally accepted that the most dangerous sizes are from 0.5 micron to 6 microns. Larger particles of dust, such as pollen, which range from 14 to 60 microns, may lodge in the nasal passages, causing an irritation known as hayfever or asthma, but they do not enter the lungs. While the composition of dust has an important relation to its effect on the human system, the size of the particle determines what part of the system it may reach. The size of the dust particle is also a very important factor in its removal from the air and provides a means of measurement. Large dust particles can readily be observed floating around in the air, especially in a darkened room with a beam of sunlight passing through. It is, however, only those particles 10 microns or more in diameter that are visible to the unaided eye, and the great masses of them are invisible except with the aid of a microscope.

The Dust Problem in Ventilation

Some of the reasons for dust presenting a difficult phase of the ventilating problem are:

(1) It is so common, practically no air being free from it.

(2) The great majority of the particles are invisible and their presence is not apparent by a casual observation.

(3) No satisfactory method of measuring the dust in the air has been standardized and accepted.

(4) The performance to be expected of different types of cleaning apparatus is uncertain, due largely to the lack of standardized methods of measurement.

The last two factors will be specifically considered in this discussion.

Many measurements have been made to determine the number of dust particles in the atmosphere, both in various types of buildings and out-of-doors. These counts range anywhere from a few hundred up to several hundred million particles per cubic foot. After the air has been washed by a snow or rain, the count may be a matter of a few hundred, while for a reasonably dry day on a busy street it may run from four to six million particles per cubic foot. A factory building, depending upon the kind of work done, may show a count from a few thousand up to hundreds of millions of particles. Thus, the number of dust particles may vary within wide limits, and it is difficult to set standards as to the amount which should be tolerated. It is evident, however, that in most cases standards should include some consideration of the size of dust particles. A relatively small number of coarse, heavy particles might give the appearance of very dirty air and do a considerable amount of physical damage without being a menace to human health. On the other hand, large quantities of fine particles might be present which might be exceedingly dangerous to health and yet not be visible or cause any particular physical damage.

Methods of Measuring Dust in Air

A standardized method of measuring dust is an important factor which as yet has not been settled. Several methods have been proposed and developed, although none has shown sufficient merit to warrant its

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being universally adopted. One common method has been to separate dust from the air and find its total weight. This has the advantage that weight is a positive measure and one that can be easily understood in making comparisons. It has the disadvantages that weight alone does not indicate the quality of the dust nor the size of the particles, and, therefore, shows nothing as to whether or not it is a harmful dust. Total weight has no relation to the number of particles of dust contained in the air. One particle 100 microns in diameter would be equivalent to 1,000,000 particles of 1 micron in diameter. Furthermore, even though the total number of particles of dust in the air may be very high, the total weight in a given volume of air is usually very low and it is a difficult procedure to thoroughly clean a sufficient quantity of air to make a weight determination practical.

A general method which seems to give the greatest promise from the standpoint of practical application is to separate the dust particles from a given quantity of air and make an actual count of them under the microscope. In addition to giving the number of particles present, some information may be obtained as to the relative sizes and shapes of the particles. There are several possible methods of separating the dust particles from the air, but the two which seem most practical and which have been used in this investigation are:

(1) To wash the dust out with water.

(2) To collect it on a viscous coated glass plate.

An apparatus for washing the dust from the air which seems to give a very high efficiency and which is used by the United States Bureau of Public Health is the Smith-Greenberg impinger. It is designed to impinge at high velocity a stream of the dust-laden air against a plate under water. For practical purposes, this instrument has been considered to give 100 per cent collection. While the instrument has the advantage of collecting a high percentage of the dust, it has some disadvantages:

(1) It takes a considerable period of time to make a determination.

(2) Some kinds of dusts are soluble in water and, therefore, not adapted to this method of collection.

(3) In many instances, dust particles float in the air in agglomerated masses rather than in individual, fine particles. In the air, many of these particles massed together might be the equivalent of one large particle, whereas when they are passed through the water impinger, they are broken up into many fine particles. The dust count thus shows a much larger number of fine particles than actually exists in the air. The extent of this error will depend upon the nature of the dust.

After the sample is collected, the particles contained in a definite volume of the collecting water are counted under a microscope.

The viscous coated impinger principle is used in several instruments, a very common one being that designed by Dr. E. V. Hill. In this instrument, a high velocity jet of air is impinged against a viscous coated glass by the rapid stroke of an air pump. The particles are then counted under a microscope, as in the previous case. The advantages of this system are that the sample is quickly taken and the apparatus is easily handled for practical measurements. As in the Smith-Greenberg, a microscopic view of the dust particles gives much information that cannot be determined by any other method. One of the disadvantages in most such instruments is the inefficiency of the collection and, also, the difficulty of getting practical samples from concentrated dust mixtures. Comparative tests between the two types of instruments have shown that for low concentration of dust the viscous impinger will give a count equal to or greater than the water impinger, but for high concentration the water impinger will show a very much higher count. In order to make the viscous collector applicable to practical conditions, the dust count obtained must be increased by some factor. This might not be a serious objection were it not for the fact that there can be no assurance that the factor is the same for all kinds and concentrations of dust.

Improvements in the Viscous Counter

Since there were some practical advantages in collecting the sample on a viscous coated slide as compared with collecting it in water, and since some kinds of dust apparently were not adapted to the water method of collection, it seemed worthwhile to consider the possibility of getting a higher percentage of dust collection by the viscous method. The Hill dust counter was selected as a basis for the first experimental work. In this work, three general changes were considered for improving the percentage of dust collected:

(1) To select the adhesive material for coating the glass collecting plate which would collect the largest percentage of dust and retain the dust in the best condition for counting under the microscope.

(2) To change the size and shape of the orifice and vary its distance from the viscous plate to get the most effective design for collecting a high percentage of dust which would fall within the field of the microscope for counting.

(3) To find the most effective velocity of air through the orifice and to devise a means for obtaining a constant uniform velocity of air for the sample.

The demands of an adhesive material for a suitable coating of the glass collecting plate are rather exacting and the selection has proved to be a very difficult part of the problem. The material must spread over the surface of the glass with a smooth, even surface. It must be viscous enough to catch and retain the fine dust particles and be sufficiently stable to retain them in position after the sample is taken, and yet not be so rigid that the particles will not adhere to the surface.

In trying out various materials, it was found that such materials as vaseline had an advantage in that they would maintain their position on the slide and not flow after the sample was taken, but they had disadvantages in that it was difficult to get a good smooth surface, and that the percentage of dust retained on the surface was very small. With many of the oils, the film would break and tend to form little drops on the surface of the plate. In some cases, this break would occur immediately, and in other cases it would break during the taking or counting of the sample.

A list of the oils tried out, together with some of the difficulties met with, follows:

(1) Vaseline—Uneven surface, very poor retention of dust.

(2) Paraffin Oil—Surface had tendency to break during counting.

(3) Paraffin oil mixed with Xylene—Some improvement over paraffin oil, but surface tended to break.

The following oils broke either immediately or while taking the sample: (4) Glycerin; (5) Olive Oil; (6) Castor Oil; (7) Cod Liver Oil; (8) Cottonseed Oil; (9) Raw Linseed Oil; (10) Boiled Linseed Oil; (11) Havoline Motor Oil; (12) Red Atlantic Lubricating Oil; (13) Lard Oil; (14) Marvel Penetrating Oil; (15) Raw Paraffin Oil.

(16) Canadian Balsa—Surface hardens and does not catch dust.

(17) Semdac Floor Oil—Difficult to focus particles but has possibilities.

(18) Oil of Cedar—Evaporates, leaving residue of particles which are mistaken for dust.

(19) Filter Oil—Reasonably satisfactory.

After many trials, the Filter Oil, No. 19 in the list, was selected as the most satisfactory. While this oil does not give a perfect coating, it was used throughout the remainder of this experimental work.

In changing the orifice, the object was to select the combination of orifice design and position of orifice relative to the plate which would give the most efficient dust collection, and a sample of such size and shape that all or a definite percentage could be brought within the field of the microscope for counting at the desired magnification.

Various kinds of orifices were used, including thin plate, short tube, rounded entrance, and narrow slits, each of different areas and at different distances from the plate. A cylindrical orifice 0.04 in. in diameter through a ⅛ in. plate with $\frac{1}{16}$in. clearance was finally selected.

For the first changes in the orifice and the coating of the viscous plate, the regular 5 cu in. suction pump was used to draw the air through the orifice against the viscous coated glass slide. The progressive changes improved the percentage of dust collection to such an extent that it was difficult to count the dust particles obtained without so reducing the stroke of the pump as to make the apparatus impractical for average dust concentration. Pumps with smaller cylinder diameters were substituted, but still many samples were overloaded with dust particles, and there was the further difficulty that the velocity of the air impinging against the surface of the slides varied from zero to a maximum with an uncertain average.

From experimental work previously reported[1], it was definitely known that the air velocity greatly affected the percentage of dust collection. The hand pump was therefore discarded and the air was drawn at constant velocity through the orifice by means of a small vacuum pump. The rate of air flow giving the best collection of dust was determined by trial. While this method was an improvement, it was still difficult to get samples of air which were sufficiently small to make the counting practical. The dust samples were concentrated in the central part of the field while the outer portions were practically clear. There appeared to be at least two ways out of this difficulty:

(1) To devise some type of shutter which would operate accurately on the split second to admit very small samples of air.

(2) To devise an arrangement for moving the orifice relatively to the viscous coated plate at a predetermined speed to distribute the dust sample over the field.

[1]Determining The Quantity of Dust in Air by Impingement, F. B. Rowley and John Beal, A. S. H. V. E. Transactions, Vol. 35, 1929, p. 483.

Both methods were tried but the second was selected as the most promising, and the counter was developed on this principle.

In its present form, the counter is designed so that the air is drawn through the orifice at a constant velocity by means of a vacuum to impinge on a viscous coated glass plate. The amount of air striking the plate at any given section is regulated partly by the size of the orifice and the air velocity through the orifice, but finally by moving the orifice parallel to the surface of the collecting plate at a predetermined constant velocity. By this arrangement, a continuous uniform path of dust particles is deposited on the plate. The width of the path is within the field of the microscope and by counting the particles for a given length of the dust path, the number per given air volume is determined.

The instrument in its present form is provided with an 0.04 in. diameter orifice through an ⅛ in. thick plate. The plate is placed $\frac{1}{16}$ in. from the viscous coated glass slide. For best results, the air is drawn through the orifice by a vacuum equal to 5 in. of mercury, and for average laboratory air a countable sample can be obtained by moving the orifice over the surface of the glass at the rate of ¾ to ¼ in. per second. This gives a volume of air of approximately 0.6 cu in. per millimeter of length for the dust path and a velocity through the orifice of 375 fps. Counts are taken for different sections of the path to give a fair average for the sample. Table 1 shows the results of counts taken at different sections of path for several samples.

Table 1—Results of Dust Counts Taken at Different Sections of Path

Sample No.	Dust Count Section A	Section B	Section C	Average	Particles per Cu Ft
1	230	210	198	212	1,293,000
2	293	326	300	306	1,865,000

The complete counts for the three sections of Sample No. 2 are given:

Section A							
7	4	9	10	4	1	2	
4	6	7	9	7	1	2	
5	2	9	10	4	5	7	
2	1	6	10	12	5	4	
3	6	8	12	10	4	9	
2	4	8	9	7	7	6	
3	6	10	10	5	7	2	Total: 293
Section B							
2	10	3	14	4	5	3	
5	7	8	4	12	8	0	
4	9	8	13	13	10	1	
0	8	10	9	17	2	5	
5	9	7	12	11	1	1	
3	8	6	9	8	7	2	
2	7	8	9	10	2	5	Total: 326
Section C							
0	2	4	6	11	3	2	
4	4	4	6	15	4	4	
1	10	5	17	6	8	0	
0	3	6	9	9	5	17	
8	2	7	9	9	6	8	
2	4	4	9	15	9	1	
3	5	4	6	11	5	8	Total: 300

The advantages of this method of sampling the air are:

(1) That the air is made to impinge against surface of the collecting plate at a uniform velocity throughout the sample.

(2) The sample from a small but definite quantity of air is spread in a uniform path on the surface of the glass and falls completely in the field of the microscope.

With an orifice which remains stationary relative to the collecting surface, it is impossible to get uniform conditions of air flow for the sample when dealing with air volumes of less than 1 cu in. Furthermore, when the sample is collected, it is concentrated in the center of the field, making it impossible to count the dust in the center squares accurately, while there are no particles at all in the outer squares of the field.

Table 2 shows the counts from two average samples of air, one taken with a stationary orifice and the other with a moving orifice. From this it will be observed that for the stationary orifice 119 or 51.7 per cent of the particles are collected in the 9 center squares, leaving only 48.1 per cent for the remaining 40 squares, while for the moving orifice the distribution is made more uniformly.

Table 2—Comparative Counts for Samples taken with a Stationary and a Moving Orifice

		Stationary Orifice					Total	
0	0	2	4	4	0	0	10	
1	2	5	8	5	6	0	27	
1	0	14	20	10	4	3	52	
3	5	12	18	12	7	4	61	
3	8	8	11	10	5	5	50	
2	1	4	1	4	3	2	17	
0	3	5	1	3	1	0	13	230
		Moving Orifice						
0	2	5	10	8	5	1	31	
0	6	10	9	3	3	1	32	
2	4	10	4	5	1	1	27	
0	6	4	7	10	6	1	34	
1	3	10	10	10	7	2	43	
0	2	16	10	8	3	2	41	
1	2	10	11	6	2	0	32	240

Comparative Dust Counts with Two Types of Impingers

Accurate comparisons between dust counts made with the water impinger and the viscous impinger developed in this work are difficult to make, due to such variables as:

(1) The possible shattering or breaking of agglomeration of dust particles by the water impinger, thus giving more particles than are actually in the air.

(2) The possibility that some of the dust particles may be soluble in water.

(3) The difference in counts obtained by letting the dust settle in the counting cell for different lengths of time.

(4) There is some question as to whether the very fine particles may be counted as easily when in water as when on the dry viscous plate.

During the first comparative tests, city water was used and a control count taken for the water impinger. By comparing these results with those obtained when using distilled water, the results were found to be very erratic and sometimes the count was two to three times higher when using city water. This variation was entirely too much to be accounted for by the initial dust in the water and seemed to be due to the precipitation of solids during the test. Since the logical procedure was to use distilled water, the main value of the comparison between the distilled and city water was to show the precautions which must be taken in making such counts. In all of the tests reported here, distilled water has been used.

While there was a considerable variation in the ratios between the counts obtained by the two methods, this ratio was always in favor of the viscous impinger and usually ranged 2:1 or better. Some of the comparative results obtained between the two instruments are shown in Table 3. These tests were taken when there was a considerable amount of fine dust in the air due to the dust storm in the surrounding country. It is possible that the high ratio in favor of the viscous impinger is due either to the fact that some of the fine dust is soluble in water and therefore does not show up in the count by the water impinger method, or perhaps the very fine particles are not visible when in the water solution. It is particularly interesting to note the ratios obtained from Tests 4, 5, and 6 which were taken on March 28. On the evening of March 27, the outside air was particularly dusty, and on the morning of March 28, just prior to the time that Sample 4 was taken in the Main Laboratory, a snowstorm set in which lasted intermittently throughout the morning. Sample No. 4, which was taken in the Laboratory shortly after the snowstorm started, probably represented the outside air with the fine dust of the night before. This showed a very high ratio in favor of the viscous impinger.

Sample No. 5 which was taken about 4 hours later would naturally represent a mixture of the original Laboratory air with some of the cleaner air filtered in from the outside. This air showed lower results for both instruments, but still a rather high ratio in favor of the viscous impinger. Sample No. 6 was taken shortly after Sample No. 5, with outside air. This was much cleaner than the Laboratory air by both methods, but still it showed a fairly high ratio in favor of the viscous impinger.

If it is assumed that the air for Test No. 5 was a mixture of the Laboratory air for Test No. 4 and outside air for Test No. 6, calculations may then be made to show the percentage of Laboratory air by either test method. If X = the percentage of Laboratory air in Sample No. 5, then for the viscous counter $1{,}220{,}000X + 377{,}000 \times (1.00 - X) = 612{,}000$, and $X = 28.8$ per cent of Laboratory air in Sample No. 5.

For the water impinger, $252{,}000X + 166{,}800 \times (1.00 - X) = 201{,}500$ or $X = 24.5$ per cent as the original Laboratory air in Sample No. 5. The close agreement of the percentages of air as calculated by the two methods is worth considering.

The above counts were taken by using a microscope of 100 magnifications, although similar relations were shown with 50 magnifications, as will be discussed later in the efficiency tests of filters. In every case, there was a greater quantity of dust shown by the dry viscous impinger.

Table 3—Comparisons between Dust Counts for Samples of the Same Air by the Water Impinger and the Viscous Impinger at 100 Diameters Magnification

Test No.	Date	Particles per Cu Ft Viscous Impinger	Particles per Cu Ft Water Impinger	Ratio of Count Viscous/Water	Notes
1	3/26/'35	1,132,000	580,000	1.95	Air from main lab.
2	3/26/'35	637,000	290,000	2.19	Air from main lab., after passing through filter.
3	3/27/'35	822,000	467,000	1.76	Air in main lab.
4	3/28/'35	1,220,000	252,000	4.84	Taken in main lab. about 10:00 A.M.; snow starting outside.
5	3/28/'35	612,000	201,500	3.04	Taken in main lab. about 2:00 P.M., after snowfall.
6	3/28/'35	377,000	166,800	2.26	Taken with outside air from 2nd floor of bldg. about 3:00 P.M.
7	3/29/'35	318,000	233,000	1.36	Taken in main lab.
8	4/15/'35	548,000	495,000	1.11	Taken with outside air from 2nd floor of bldg. Large wind-blown particles more easily detected in Smith-Greenberg, reducing ratio.
9	4/18/'35	2,010,000	412,000	4.86	Taken in main lab. Janitor began sweeping, increasing the dust concentration.
10	4/18/'35	1,431,000	106,100	13.47	Taken in 2nd floor room. Particles very small; still air conditions.

Since the viscous counter takes practically an instantaneous sample there will be some variations due to the natural variation of dust count in the air. Table

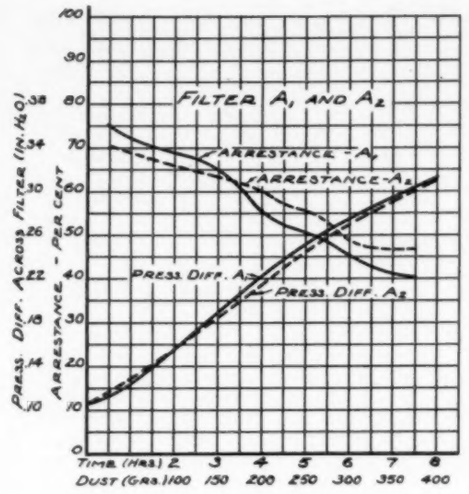
FILTER A, AND A2
ARRESTANCE - A1
ARRESTANCE - A2
PRESS. DIFF. A1
PRESS. DIFF. A2
PRESS. DIFF. ACROSS FILTER (IN. H2O)
ARRESTANCE - PER CENT
TIME (HRS.) 2 3 4 5 6 7 8
DUST (GRS.) 100 150 200 250 300 350 400

Fig. 1—Test Results of Filter *A*

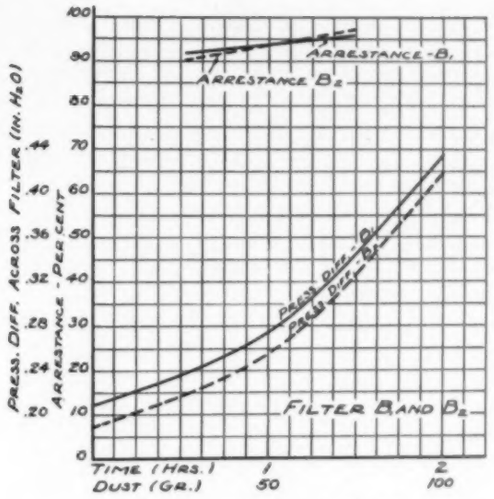

Fig. 2—Test Results of Filter *B*

4 shows the results from samples taken at successive, short intervals of time. The variation in count is not excessive but indicates that for average conditions more than one sample should be taken.

Table 4—Variation in Count for Dust Samples taken with the Viscous Counter at Successive Intervals of approximately 2 Min

Date	Sample No.	Dust Particles per Cu Ft	Percent Variation from Average
3/6/'35	1	836,000	+15.0
	2	680,000	— 6.5
	3	600,000	—17.5
	4	793,000	+ 9.1
	Average:	727,000	
3/7/'35	1	1,000,000	+12.2
	2	829,000	— 6.9
	3	845,000	— 5.2
	Average:	891,000	
3/11/'35	1	418,000	+ 7.7
	2	290,000	—25.2
	3	376,000	— 3.1
	4	469,000	+20.8
	Average:	388,000	
3/12/'35	1	327,000	— 2.9
	2	312,000	— 7.4
	3	372,000	+10.4
	Average:	337,000	

Rating the Efficiency of Dust Cleaners

The rating of dust cleaning apparatus has always been a troublesome problem, largely due to the fact that no standard method has ever been adopted for measuring the amount of dust in the air. For several years, a committee of the American Society of Heating and Ventilating Engineers worked on the problem and, after considering the various methods available for measuring dust, finally prepared the A.S.H.V.E. Standard Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work in which a given kind of dust was used and the percentage of total weight retained by the filter taken as a measure of its efficiency.

The dust prescribed in this code consists of a mixture of 50 per cent by weight of powdered lamp black and 50 per cent by weight of ashes of Pocahontas bituminous coal screened to pass the 200-mesh sieve. Since the code is for the purpose of determining the dust-holding capacity of the filter as well as its efficiency or arrestance, it must necessarily provide an accelerated test. 0.65 grams of dust per 1,000 cu ft of air are therefore prescribed. The mixture of dust is fed into the air by a specially designed dust mixer, and the amount passing through the filter is obtained by thoroughly cleaning a certain fraction of the air passing through and weighing the dust thus obtained.

This code serves a useful purpose, and the following comparisons are not to criticize it but rather to examine some parts of it, together with the results obtained by its use, to see whether or not it provides everything that is desirable in the rating of an air filter. There is a question as to whether the particular dust prescribed, together with the method of feeding it in concentrated form to the filter, represents practical conditions. These dust particles may have a tendency to remain in agglomerated masses and not to separate out into individual, fine particles as they would in practice. If this should be the case, certain types of filters might collect a much larger percentage of the weight of dust in the air during a performance test than they would during practical operations.

On the other hand, there may be the question of overloading certain viscous types of filters and not giving the oil-coated fibers the same chance of collecting the dust that they would have in normal operation. Next, there is the question that even if the arrestance by test represents a true percentage of the weight of dust which would be taken out in normal operation, there is still a doubt as to whether weight alone gives everything that is desirable when considering filter efficiency. It is evident that a few large particles which would be taken out easily by a filter may represent a large percentage of the weight of a given mass of dust and yet may not at all be representative of the dust in the mixture or of the dust which is or is not taken out by the filter. If these dust particles were 10 or more microns in diameter, each one of them would equal the weight of 1,000 or more of particles 1 micron in diameter. The filter might be taking out the large particles, thus showing a very creditable efficiency, while it would be passing all of the very fine particles which might be the real dangerous dust insofar as ventilation is concerned.

In order to check the possible difference in the rating

of filters by the A.S.H.V.E. Standard Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work and by the dust count method, four typical filters have been selected and designated as Filters *A*, *B*, *C*, and *D*. Filters *A* and *B* were rated by the standard code method and the ratings are shown by the curves of Figs. 1 and 2. Filter *C* has been tested and found to be from 95 to 98 per cent efficient for dust particles 14 microns in diameter or greater. The 4 filters were placed in the standard test apparatus and their efficiencies determined by the dust count method when using both the water and viscous impinger. The tests were not made with the heavy dust concentration as prescribed by the code, but rather by passing the normal laboratory air through the filters and taking dust counts of the entering and leaving air. The results of these tests are shown in Tables 5, 6, 7 and 8.

By comparing the test results for Filters *A* and *B* when using the two different methods, it will be noted that for Filter *A* the standard code gave an efficiency of 72 per cent for the filter when new, while the dust count method gave an efficiency of 41.5 per cent. For Filter *B* a test by the standard code gave an efficiency of 91 per cent for the new filter, while the dust count method gave an efficiency of 52 per cent. The ratio of the efficiencies by the dust count method to the standard code method is 57.6 per cent for Filter *A* and 57 per cent for Filter *B*. The rating curves for Filters *C* and *D* by the standard code method are not available. However, Filter *C* was found to have from 95 to 98 per cent efficiency when using lycopodium powder, the size of particles being about 14 microns.

The comparative test results for the different filters would indicate that the efficiency of the average filter in normal operation might be expected to be lower when determined by the dust count method than when determined according to the standard code. It seems reasonable to believe that this difference is partly due to the fact that the filter is more efficient for large than for small particles. The number of particles counted in any case will depend upon the magnification. For a magnification of 100 diameters, particles of 1 micron are easily counted, and a study under different magnifications indicates that on the viscous coated slides particles of ½ micron in diameter may be included. This varies with the individual making the count, but as a lower limit it appears that particles ½ micron in diameter may be included. At 50 diameters magnification the same study indicated that particles 1 micron in diameter may be included. For Filter *A* the efficiencies were taken by using both 50 and 100 diameter magnifications. The final results were substantially the same.

In order to determine the differences in numbers of particles counted when using 50 and 100 diameter magnifications, several comparative counts were made for different samples without moving the sample under the microscope. The results are shown in Table 9. While there is some variation in the percentages obtained by 50 diameters magnification, the average is 48 per cent of the number obtained by 100 diameters magnification. This would indicate that of the average dust floating in the air, approximately 50 per cent of the particles visible at 100 diameters magnification are 1 micron or below in diameter. Since substantially the same efficiencies were obtained on the filters when using 50 and 100 diameters magnifications, it appears that the filter must be taking out approximately the same percentage of the particles of the different diameters.

As a further check on the reliability of requirements as set up by the standard test code, a sample of each, the carbon black and Pocahontas Ash as used in the standard code, was investigated to determine the size of particles when collected by the two different instruments and, also, when mixed in the air for the filter tests.

For this examination, each dust was fed separately into the air stream of the test apparatus by the standard dust-mixing device, and samples were taken by both instruments and also by glass slides placed in the air stream. The purpose of using the glass slides was to

Table 5—Efficiencies of Filter *A* by Dust Count Method

Test No.	Date	Test Method	Magnification	Count Upstream	Count Downstream	Eff. %	Notes
1	3/22/'35	Viscous	100	2,010,000	1,144,000	43	
2	3/23/'35	Viscous	100	853,000	659,000	22	
3	3/23/'35	Viscous	50	495,000	339,000	32	(Same sample (as for Test 2
4	3/24/'35	Viscous	100	1,647,000	1,165,000	29	
5	3/25/'35	Viscous	50	1,020,000	665,000	35	(Same sample (as for Test 4
6	3/26/'35	Viscous	100	1,133,000	636,000	44	
7	3/26/'35	Viscous	50	620,000	322,000	48	(Same sample (as for Test 6
8	3/26/'35	Water	100	580,000	290,000	50	(Taken same (time as No. 6
9	3/26/'35	Water	50	294,000	115,000	61	(Same sample (as for Test 7
10	3/27/'35	Viscous	100	980,000	580,000	41	
	3/27/'35	Viscous	50	790,000	448,000	43	
11	3/29/'35	Viscous	100	1,077,000	569,000	47	
12	3/30/'35	Viscous	100	514,000	245,000	52	
13	3/30/'35	Viscous	100	358,000	237,000	34	
					Average:	41.5	

Table 6—Efficiencies of Filter *B* by Dust Count Method

Test No.	Date	Test Method	Magnification	Count Upstream	Count Downstream	Eff. %
1	4/2/'35	Viscous	100	764,000	363,000	53
2	4/2/'35	Viscous	100	971,000	662,000	32
3		Viscous	100	1,140,000	484,000	57
4		Viscous	100	1,314,000	784,000	40
5		Viscous	100	2,735,000	1,033,000	62
6		Viscous	100	2,095,000	653,000	69
					Average:	52

Table 7—Efficiencies of Filter *C* by Dust Count Method

Test No.	Date	Test Method	Magnification	Count Upstream	Count Downstream	Eff. %	Notes
1	4/4/'35	Viscous	100	3,580,000	870,000	76	200 fpm
2	4/4/'35	Viscous	100	5,770,000	2,480,000	57	200 fpm
3	4/4/'35	Viscous	100	2,830,000	1,075,000	62	200 fpm
4	4/4/'35	Viscous	100	2,420,000	1,407,000	42	200 fpm
5	4/4/'35	Viscous	100	952,000	617,000	35	200 fpm
6	4/5/'35	Viscous	100	1,418,000	571,000	60	200 fpm
7	4/5/'35	Viscous	100	1,475,000	466,000	68	200 fpm
8	4/8/'35	Viscous	100	1,343,000	625,000	53	90 fpm
9	4/8/'35	Viscous	100	1,109,000	528,000	52	90 fpm
10	4/8/'35	Viscous	100	835,000	256,000	69	45 fpm
11	4/8/'35	Viscous	100	1,047,000	528,000	50	45 fpm
					Average:	56.7	

Table 8—Efficiencies of Filter *D* by Dust Count Method

Test No.	Date	Test Method	Magnification	Count Upstream	Count Downstream	Eff. %	Notes
1	4/16/'35	Viscous	100	1,384,000	584,000	58	(250 fpm (0.19 pres. drop
2	4/16/'35	Viscous	100	1,485,000	806,000	46	
3	4/19/'35	Viscous	100	1,992,000	1,590,000	20	
4	4/19/'35	Viscous	100	852,000	468,000	45	
5	4/19/'35	Viscous	100	900,000	645,000	28	
					Average:	39.4	

Table 9—Ratio between Total Numbers of Particles Counted at 50 and at 100 Magnification for Both Water and Viscous Impinger Method

Test No.	Date	Method	Location	Magnification 100	Magnification 50	Percentage at 50 Mag.
1	3/23/'35	Viscous	Upstream	854,000	328,000	38
2	3/23/'35	Viscous	Downstream	660,000	224,000	34
3	3/25/'35	Viscous	Upstream	1,648,000	1,022,000	61
4	3/25/'35	Viscous	Downstream	1,165,000	666,000	57
5	3/26/'35	Viscous	Upstream	1,205,000	384,000	32
6	3/26/'35	Viscous	Upstream	970,000	482,000	50
7	3/26/'35	Viscous	Downstream	279,000	142,000	51
8	3/26/'35	Viscous	Upstream	1,134,000	620,000	55
9	3/26/'35	Viscous	Downstream	636,000	322,000	51
10	3/26/'35	Water	Upstream	580,000	294,000	51
11	3/26/'35	Water	Downstream	290,000	115,000	40
12	3/27/'35	Viscous	Upstream	980,000	524,000	53
13	3/27/'35	Viscous	Downstream	580,000	296,000	51
					Average:	48

Table 10—Samples of Standard Dust Collected by the Viscous Filter and the Water Impinger for Examination under the Microscope to determine the Percentages of Different Sized Particles in Samples

	Viscous Impincer	Water Impinger
Carbon Black		
2 Microns or less, percentage	80	85
2 to 5 Microns, percentage	15	14
5 Microns or over, percentage	5	1
Pocahontas Ash (Through 200-mesh Sieve)		
2 Microns or less, percentage	82	50
2 to 5 Microns, percentage	14	40
5 Microns or over, percentage	4	10

Table 11—Estimated Size of Particles collected on Glass Slides placed in the Air Stream of Standard Filter Test Apparatus

	Dry Glass Slide	Oil Coated Slide
Pocahontas Ash		
2 Microns or below, percentage	20	Negligible
2 to 5 Microns, percentage	45	35
5 to 10 Microns, percentage	25	45
Above 10 Microns, percentage	10	20
Carbon Black		
2 Microns or below, percentage	55	30
2 to 5 Microns, percentage	30	50
5 to 10 Microns, percentage	10	10
Above 10 Microns, percentage	5	10

collect the dust particles in the condition in which they would reach the test filter, that is, without danger of breaking up the aggregations of particles. In each case, the dust was collected on a dry glass plate, an oil coated plate, and both impingers. They were examined under the microscope to make an estimate of the percentage of the different sized particles collected. The results of this investigation are shown in Tables 10 and 11.

Referring to Table 10, the samples of carbon black showed substantially the same results by the viscous and water impingers. For the Pocahontas Ash, there appeared to be a larger percent of fine particles in the sample collected by the viscous impinger. This may have been due to a less efficient collection by the water impinger to the solubility of some of the dust, or perhaps the finer particles were invisible in the water solution. The total number of fine particles for both types of dust appears to be fairly satisfactory.

Referring to Table 11, it will be observed that the samples collected on the glass slides show the average diameter of particles to be decidedly greater than for the samples collected by either of the impingers. The oil coated slides collected a much smaller percentage of fine particles than did the dry slides. In the case of Pocahontas Ash, the oil coated slides showed 65 per cent of the particles to be 5 microns or above, while the viscous impinger showed only 4 per cent of 5 microns or above. The percentage of fine particles of carbon black collected on the glass slide was more nearly equal to those collected by the impingers, although there was still a very much larger percentage of coarse particles obtained. While the collection on the glass slides cannot be considered to be 100 per cent perfect, it does show that the dust particles are not broken up and as finely divided in the air stream as they should be. This is quite likely one reason why the filters tested by the standard code method show a higher efficiency than when tested by the dust count method under operating conditions.

From the results obtained in the investigation, it would seem reasonable to give some consideration to the standard method of testing air filters to see whether or not the code provides everything that is required of a filter in normal operation. The important factor in rating a filter is often not that it takes out a certain percentage of dust by weight, but rather that it will take out certain objectionable dusts. In some cases, it may be the very fine dust and, in other cases, it may be the coarser particles that should be removed. The efficiency of a filter rated on the weight basis might have no relation to its efficiency when rated by the dust particles as found in normal air. A count method is easily applied to a filter either under test conditions or in normal operation, and there seems to be no reason why an efficient and adaptable counting instrument cannot be designed.

The rating of filters for different sized dust particles might be effected by estimating the percentages of dust particles of different diameters under a high magnification, or the magnification might be reduced to such an extent as to make only those particles visible which are in the range of sizes required of the filter. For instance, if a filter were to be used to clean the air of fine particles of silica dust which might enter the lungs, the dust count would be made under 100 magnification. If, on the other hand, the filter were to be used to clean out only the large particles, such as might be required for hay fever patients, then the dust count might be made at 10 or 20 magnification and the finer particles eliminated from consideration. Such a procedure would greatly facilitate the testing of filters in actual operation. It would not necessarily replace the present code but would be a valuable supplement to it and would give much desirable information as to filter efficiency.

Bureau of Mines Activities To Be Expanded

An appropriation of $1,970,311 to the Bureau of Mines for the new fiscal year beginning July 1 is made in the Interior Department supply bill which has been signed by the President. This amount includes a net increase of approximately $600,000, granted in response to numerous appeals that the Bureau be given sufficient funds to resume many important services that had been discontinued or curtailed during past years, and to undertake important new work that lack of funds had hitherto prevented.

According to an announcement recently made by the Bureau, investigations of health hazards in the mineral industries, which were suspended two years ago, will be resumed. This work includes studies of harmful dusts and gases and other causes of occupational diseases contracted by miners.

The Bureau will expand its studies on low-temperature carbonization of coal in the effort to find a solution for the smokeless-fuel problem and thus prevent waste of fuel value in the soot and tar composing the smoke and avoid damage to buildings, clothing, etc.; to accelerate the development by the industry of commercial carbonizing processes; and to determine the composition of byproduct oils and tars and develop commercial uses for them. Apparatus on a small, laboratory scale will be constructed to study the extraction of motor fuel from coal and lignite.

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Air Supply to Classrooms in Relation to Vent Flue Openings

By **F. C. Houghten* *(MEMBER)*, Carl Gutberlet,** and M. F. Lichtenfels*** *(NON-MEMBERS)***
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THE need for providing vent stack openings in class rooms supplied with air for ventilation by mechanical means has been questioned by many engineers and representatives of school operation and administration. The work of the A.S.H.V.E. Research Laboratory[1] on infiltration demonstrated that a very small pressure difference between the two sides of a wall resulted in a high air change. Studies[2] at the University of Wisconsin have shown that in a few rooms studied the elimination of vent openings resulted in a relatively small decrease in the air supply to a room by a given fan. The Pennsylvania School Heating and Ventilation Commission, appointed to formulate a code governing the installation of heating and ventilating systems in school buildings in the State, debated the question of requiring vent openings in class rooms. Because of the lack of concrete data on the subject, the requirement for vent stacks was included in the code, but the question of their necessity was also included in the report with the suggestion that the engineering profession supply data on which an intelligent disposition of the subject might be based in the future.

In a discussion of the subject the following questions naturally arise:

1. To what extent will the elimination of vent openings in a class room receiving air from either a central fan system or a unit ventilator reduce the air delivery to the room; or, to what extent will the air pressure in such a room have to be raised above the outside pressure or that pertaining in the corridor in order to maintain the same air supply with the vent opening closed?
2. What effect will the elimination of vent openings have on air distribution throughout the room?
3. What effect will the elimination of vent stack openings have on the temperature gradient between the floor and ceiling?

The A.S.H.V.E. Research Laboratory is engaged in a study of the relation between characteristics of air supply to a class room and drafts in schools in the Pittsburgh district. In connection with this study it was found convenient to make a few observations of the effect of eliminating vent stack openings on the ventilation of class rooms. The study included observations in all class rooms in the Woodlawn Avenue School at

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[1]Air Leakage Through Openings in Buildings, by F. C. Houghten and C. C. Schrader. A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924 p. 105. (See also, subsequent reports of studies on infiltration by the A.S.H.V.E. Research Laboratory in the TRANSACTIONS of the Society).

[2]Investigation of Air Outlets in Class Room Ventilation, by G. L. Larson, D. W. Nelson and R. W. Kubasta. A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 463.

For presentation at the 41st Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Toronto, Ont., June, 1935.

Table 1—Results of Study in Woodlawn and Shaler Schools

ROOM NO	LENGTH OF ROOM FEET (EXTERIOR DIMENSION)	WIDTH OF ROOM FEET	VOLUME OF ROOM CU FT	NO OF WINDOWS	EXPOSURE	WIND VEL. AND DIRECTION	AIR DELIVERED BY UNIT VENTILATOR — VENT OPEN: VELOCITY FT/MIN	VENT OPEN: VOLUME CFM	VENT OPEN: AIR CHANGES/HR	VENT CLOSED: VELOCITY FT/MIN	VENT CLOSED: VOLUME CFM	VENT CLOSED: AIR CHANGES/HR	% DECREASE IN AIR DELIVERY WITH VENT CLOSED	DIFFERENCE FROM TO CORRECTION INCHES WATER GAUGE: VENT OPEN	DIFFERENCE FROM TO CORRECTION INCHES WATER GAUGE: VENT CLOSED
WOODLAWN AVE SCHOOL															
101	32'0"	22'4"	8576	3 *	EAST	6SW	L 531	1252	8.76	477	1125	7.87	10.1	.0001	.0435
							H 892	2094	14.37	713	1678	11.74	19.9	.0036	.0684
102	38'5"	22'4"	10296	3	EAST	5SW	L 560	1321	7.70	503	1184	6.91	10.2	.0060	.0610
							H 771	1812	10.56	691	1630	9.50	10.0	.0719	.0992
103	32'0"	22'4"	8576	3	EAST	6SW	L 527	1243	8.70	480	1132	7.92	8.9	.0244	.0633
							H 752	1845	13.03	716	1686	11.77	9.7	.0249	.1203
104	32'0"	22'4"	8576	3	EAST	6SW	L 543	1285	9.06	476	1123	7.86	13.3	.0377	.0946
							H 750	1763	12.33	657	1550	10.84	12.1	.0374	.0933
105	28'0"	28'8"	7392	2	WEST	5W	L			462	1060	8.84			.0410
							H 778	1830	14.87	622	1462	11.87	20.1	-.0017	.0700
106	28'0"	22'0"	7392	3	WEST	6SW	L 386	914	7.42	351	833	6.76	8.9	-.0218	.0173
							H 563	1322	10.73	536	1260	10.23	4.7	-.0032	.0880
AVERAGE FIRST FLOOR							L 501	1206	8.33	459	1081	7.49	10.4	.0125	.0490
							H 756	1774	12.25	656	1544	10.89	13.0	.0277	.0848
201	32'0"	22'4"	8576	3	EAST	4W	L 494	1162	8.11	503	1184	8.26	-1.9	-.0010	.0361
							H 718	1693	11.84	641	1509	10.55	10.8	.0016	.0516
202	38'5"	22'4"	10296	3	EAST	4W	H 845	1977	13.82	761	1790	12.52	9.5	.0032	.0709
203	32'0"	22'4"	8576	3	EAST	3NW	L 345	1281	7.47	450	1062	6.19	17.7	.0070	.0014
							H 760	1788	10.42	680	1724	8.90	14.5	.0031	.0378
204	32'0"	22'4"	8576	3	EAST	6NW	L 496	1122	7.85	410	969	6.78	13.6	-.0091	.0222
							H 700	1646	11.52	602	1416	9.80	14.1	-.0026	.0496
205	28'0"	22'0"	7392	2	WEST	6NW	L 487	1147	8.02	421	992	6.96	13.3	-.0159	.0224
							H 784	1842	12.89	648	1525	10.67	17.2	-.0067	.0636
							L			440	1038	8.43			.0512
206	28'0"	22'0"	7392	3	WEST	6SW	H 635	1492	10.11	604	1420	11.53	4.8	.0398	.0620
							L 452	1158	9.40	440	1038	8.43	10.4	.0097	.0374
LIBRARY	46'10"	22'0"	12144	3	WEST	7SW	H 756	1660	13.47	641	1508	12.24	9.6	.0267	.0707
							L 433	1022	5.05	318	757	3.74	25.8	-.0231	.0780
AVERAGE SECOND FLOOR							H 624	1472	7.27	486	1142	5.64	22.2	-.0118	.0877
							L 498	1172	7.82	424	1004	6.97	14.2	.0012	.0323
							H 722	1696	11.64	622	1462	10.11	13.7	.0071	.0674
301	32'0"	22'4"	8576	3	EAST	3W	L 489	1175	8.22	424	1048	7.33	10.8		
							H 745	1800	12.59	632	1520	10.63	15.2		
302	38'5"	22'4"	10296	3	EAST	8NW	L 498	1192	6.85	433	1027	5.98	12.4	.0104	.0722
							H								
303	38'5"	22'4"	8576	3	EAST	7NW	L 554	1362	9.11	492	1158	8.10	11.1	.0131	.0619
304	32'0"	22'4"	8576	3	EAST	7NW	L 436	1089	7.28	428	1011	7.07	1.9	.0083	.0378
305	28'0"	22'0"	7392	3	WEST	6W	L 572	1343	10.90	434	1023	8.32	23.7	.0804	.0438
							H 884	2080	16.86	734	1768	14.03	17.8	.0080	.0568
306	28'0"	22'0"	7392	3	WEST	5W	L 469	1105	8.57	419	990	8.04	10.4	.0085	.0270
							H 706	1660	13.47	642	1510	12.26	9.1	.0256	.0608
307	46'10"	22'0"	12364	3	WEST	5W	L 519	1221	5.93	457	1078	5.23	11.7	-.0003	.0240
							H 805	1890	9.17	665	1570	7.62	16.9	-.0003	.0428
AVERAGE THIRD FLOOR							L 507	1192	8.18	447	1048	7.18	12.2	.0022	.0444
							H 782	1843	13.07	660	1552	11.13	15.1	.0127	.0522
AVERAGE ALL FLOORS							L 502	1181	8.11	442	1043	7.27	12.4	.0043	.0432
							H 756	1769	12.27	648	1528	10.74	13.3	.0158	.0681
SHALER HIGH SCHOOL															
101	39'2"	22'0"	10348	6 **	SOUTH EAST	7W	498	961	6.39	475	917	5.33	4.6	.0017	.0220
102	38'7"	22'0"	8592	5	SOUTH EAST	6W	683	1318	9.21	623	1202	8.39	8.8	.0017	.0506
103	26'1"	22'0"	6880	4	SOUTH EAST	4NW	588	723	6.30	550	676	5.89	6.5	.0000	.0225
105	35'0"	22'0"	9240	5	SOUTH WEST	5NW	550	1062	6.89	521	1006	6.53	5.3	.0017	.0213
106	26'1"	22'0"	6880	4	SOUTH WEST	6W	680	836	7.28	620	763	6.64	8.8	.0035	.0478
AVERAGE FIRST FLOOR							600	980	7.04	558	913	6.56	6.8	.0017	.0328
201	26'3"	22'0"	6930	4	SOUTH EAST	8NW	718	883	7.65	670	824	7.13	6.7	.0000	.0387
204	26'0"	22'0"	6864	4	SOUTH WEST	7NW	697	857	7.49	630	775	6.77	9.6	.0052	.0490
209	26'4"	22'4"	6951	4	SOUTH WEST	7NW	679	835	7.21	620	763	6.59	8.6	.0066	.0813
210	26'0"	22'0"	6864	4	SOUTH WEST	6NW	590	676	5.81	519	638	5.58	5.6	.0035	.0364
211	33'0"	22'0"	8712	5	NORTH WEST	6NW	470	807	6.24	440	849	6.85	6.4	.0000	.0404
213	26'3"	22'0"	6936	4	NORTH WEST	6NW	600	738	6.39	524	645	5.58	12.8	.0052	.0681
AVERAGE SECOND FLOOR							618	846	6.85	567	749	6.25	8.2	.0034	.0520
302	26'0"	22'0"	6864	4	SOUTH EAST	9NW	737	980	8.54	680	849	7.43	13.4	.0115	.0484
305	26'0"	22'0"	6864	4	SOUTH WEST	8NW	545	670	5.85	495	609	5.32	9.2	.0082	.0578
306	26'0"	22'0"	6864	4	SOUTH WEST	8NW	727	894	7.81	653	803	7.02	10.2	.0069	.0526
308	28'0"	22'0"	7392	4	SOUTH WEST	9NW	779	958	7.78	700	861	6.99	10.4	.0024	.0850
310	39'6"	22'0"	10428	6	NORTH WEST	9NW	547	1247	7.17	505	1151	6.62	7.7	.0005	.0346
AVERAGE THIRD FLOOR							679	950	7.44	609	855	6.68	10.2	.0059	.0497
AVERAGE ALL FLOORS							632	915	7.12	578	839	6.50	8.4	.00346	.0449
AVE. ALL TESTS IN WOODLAWN SCHOOL WITH 27°F OUTSIDE TEMPERATURE							LOW SPEED / HIGH SPEED	1189 / 1732			1063 / 1514		12.8 / 13.5		
AVE. ALL TESTS IN WOODLAWN SCHOOL WITH 35°F OUTSIDE TEMPERATURE							L	1149			1041		9.2		
							H	1890			1520		12.5		
AVE. ALL TESTS IN WOODLAWN SCHOOL WITH 46°F OUTSIDE TEMPERATURE							L	1068			1016		14.5		
							H	1772			1528		13.3		
AVE. ALL TESTS IN WOODLAWN SCHOOL WITH ROOMS FACING EAST							L	1127			961		14.3		
							H	1803			1490		13.7		
AVE. ALL TESTS IN WOODLAWN SCHOOL WITH ROOMS FACING WEST							L	1215			1085		10.8		
							H	1884			1591		13.0		

* GLASS AREA PER WINDOW = 44.8 SQ. FT.
** GLASS AREA PER WINDOW = 26.8 SQ. FT.
*** L - UNIT OPERATING AT LOW SPEED
M - " " " INTERMEDIATE SPEED
H - " " " HIGH SPEED

Munhall, Pa., mentioned in an earlier Laboratory report[3], and in 16 of the class rooms in the Shaler High School, near Pittsburgh.

All classrooms in both schools were provided with vent flue openings extending to the outside at the roof of the building. The openings in the Woodlawn school were 20 in. wide by 38 in. high, with the bottom of the opening about 10 in. above the floor line. In most instances the vent flue openings were located in cloak rooms provided with doors extending down to 6 in. from the floor. The cloak room doors were always kept closed during a test. There were no vent openings between the rooms and corridors. The doors were reasonably tight around the sides but had clearances of from ⅛-in. to ½-in. at the bottom. All windows were weatherstripped.

The corridors in the schools were not provided with vent openings, but in order to insure against building up of a pressure in the corridor due to air leakage into them during a test, a corridor window on the floor on which a test was being made and on the side of the building least affected by the wind was opened. The corridors were therefore at atmospheric pressure and the results of the study should be typical of schools in which the corridors are amply vented to allow the escape of air leaking into them from classrooms not having vent openings into flues or into the corridors.

Each classroom was provided with one or two auxiliary radiators depending on the location of the unit ventilator. Where the unit was in the center of the exposed wall there were two auxiliary radiators, one on each side of the unit. Where the unit was at either end of the exposed wall there was a single auxiliary radiator at the other end.

In preparing for a study in any room, an inclined manometer was placed in the room near the door, with one leg connected to a ⅛-in. brass tube extending under the door to the corridor so as to indicate the pressure difference between the inside of the room and the corridor. A calibrated anemometer was placed on the unit ventilator outlet grille at a point near the center which was found to give an approximately average outlet velocity. This anemometer was not moved during the test. In making the study in a few of the rooms, thermometers were placed,—6 in. from the floor, 30 in. from the floor, 63 in. from the floor, 101 in. from the floor, and 6 in. from the ceiling,—in a location in the plan of the room which was half-way between the exposed wall and the corridor wall, and approximately one-third of the way from the front or rear wall to a line through the center of the unit ventilator. In rooms where the unit ventilator was not placed in the center of the exposed wall, this location was chosen in the end of the room having the greater distance from the front or rear wall to the center of the unit ventilator. Other thermometers were placed on the desks in different portions of the room in order to indicate any variation in temperature at this level.

Observations were taken at frequent intervals of the thermometers giving the temperature gradient from the floor to the ceiling, and the temperature variation at the level of the tops of the desks, the pressure difference between the room and the corridor, and the reading of the anemometer located on the unit ventilator outlet grille, over a period of 20 min or more, with the vent open and the unit ventilator operating as installed. All windows and doors were closed as in normal practice. At the end of this period the vent stack opening was completely closed and the observations were continued during another 20 min interval or longer.

The unit ventilators in the Woodlawn school could

[3]Class Room Odors with Reduced Outside Air Supply, by F. C. Houghten, H. H. Trimble, Carl Gutberlet and Merle F. Lichtenfels. A.S.H.V.E. Journal Section (*Heating, Piping and Air Conditioning*), May, 1935.

be operated at low, intermediate, and high speed by a switch conveniently located in the unit. Most of the units in the school were normally operated at low speed. Observations were made on the effect of closing the vent with both the low and high speeds in all the rooms, and with the intermediate speed also in a few cases. In the Shaler school observations were only made with the unit ventilator running at the speed normally used.

The results of the study in the rooms of the two schools are given in Table 1. The study in the Woodlawn school extended over a considerable period of time and included observations on days with different outside temperatures. The observations in the Shaler school were made on a single day later, with a higher outside temperature.

When the units were operating at low speed in the Woodlawn school they delivered from 914 to 1,343 cfm to the different rooms, based upon the measured outlet velocities and grille areas. For these conditions the different rooms showed percentage reductions in the volume of air delivery with the vent closed ranging from 1.7 to 25.9 per cent of the delivery with the vent open; the highest decrease, 25.9 per cent, was found for the library.

With the unit ventilators operating at high speed in the Woodlawn school the air delivery rate was naturally higher, and the percentage decrease with vents closed was greater, ranging from 4.7 to 22.2 per cent of the delivery with the vents open.

The table also gives averages for different conditions pertaining during the different tests in the Woodlawn school, including outside temperatures of approximately 27 F, 35 F and 46 F, the floor on which the rooms were located, the direction of exposure of the rooms, and for the entire series. These data show no consistent variation in reduction of air delivery with any of these variables.

The results of the tests in a few of the rooms are shown in Fig. 1, where the air delivery by the unit ventilator is plotted against pressure difference between the room and the corridor for the two unit ventilator speeds and with the vents closed in the Woodlawn school. The curves show a wide variation in the relation between pressure drop and delivery for the different rooms, but they all show similar characteristics to curves for air flow through orifices. A single orifice curve is plotted as a broken line for a value of $CA = 1.598$. If for this curve an orifice constant, $C = 0.6$, is assumed, a resulting orifice area of 383 sq in. would be indicated, bearing out the findings of the infiltration studies, that the equivalent orifice area of all the avenues of leakage from a room is inconceivably large. The room number and outside temperature for each of the curves are indicated.

The results of the various tests plotted in Fig. 1 and tabulated in Table 1 indicate no definite correlation between the reduction in air supply resulting from closed vents, and the outside temperature, wind velocity, or size of room. The reduction seems rather to depend upon individual room construction.

The air delivery for an intermediate unit ventilator speed is also plotted in Fig. 1, for room 201. It is of interest to observe from the air delivery values for open and closed vents with units operating at different speeds, as tabulated in Table 1, that the reduction in air delivery due to closing the vent with the unit operating at low speed is considerably less than the increase in delivery with closed vent and the unit operating at the next higher or intermediate speed; in other words, decrease in delivery resulting from closing the vent opening may be overcome by an increase in speed of operation of the unit within the range of adjustments pro-

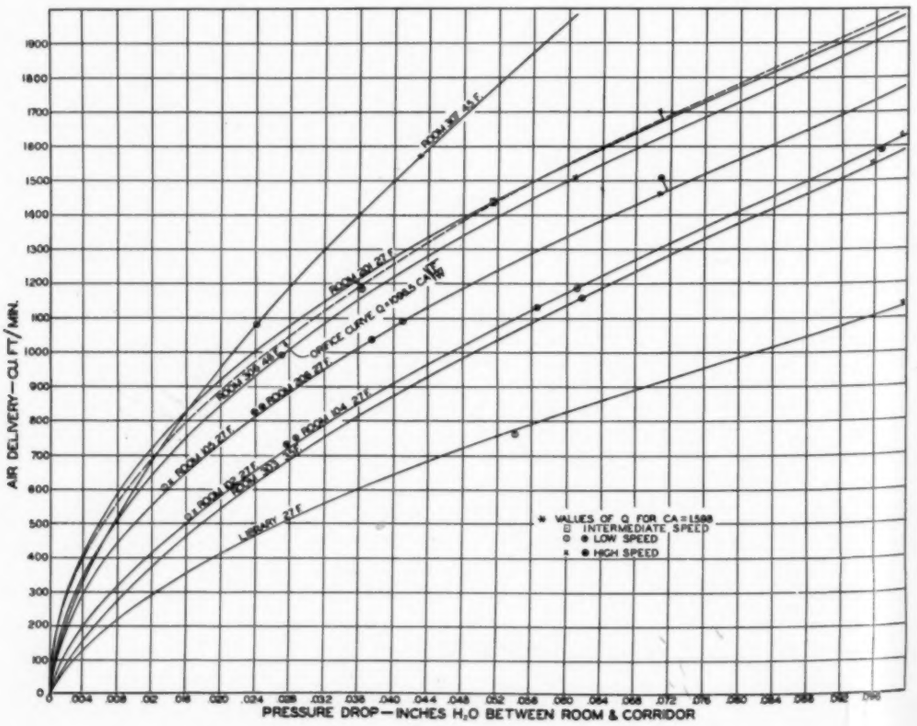

Fig. 1—Relation between pressure drop from room to the corridor and air delivery with the vent closed for high and low speed operation of the unit—Woodlawn School

vided in the particular units used in the Woodlawn school.

Closing the vent opening in any room with few exceptions increased the temperature gradient from the floor to the ceiling. For the rooms in which the temperature gradients were studied, this resulted in an increase in the gradient of approximately 1 deg. The temperature gradients for a number of cases studied are plotted in Fig. 2, in which the slight difference in

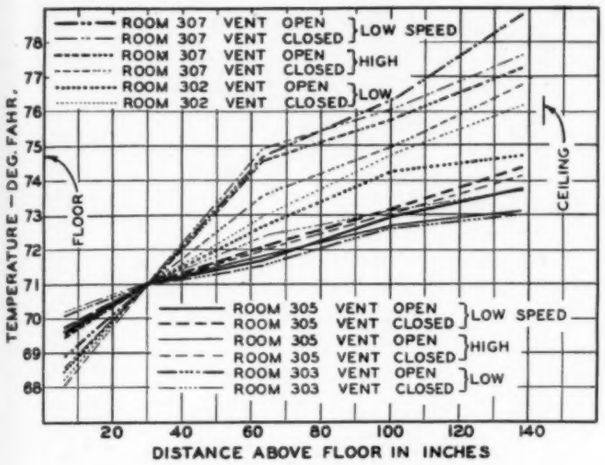

Fig. 2—Temperature gradients, floor to ceiling

temperatures at the 30-in. level is adjusted to their average temperature of 71 F in order to give a better comparison. Actually, the temperature at the 30-in. level varied by as much as three-fourths of a degree for these tests. The curves indicate temperature gradients from floor to ceiling ranging from 3 to 10 deg.

Only in room 307 was the temperature gradient from the floor to the ceiling less with the vent closed than with it open. This room was somewhat larger than the average room in the building and had a lower room air change under normal operation of the unit, which undoubtedly accounts for the greater temperature gradient between the floor and ceiling with the vent open for the same unit speed than found for the other rooms. In all cases observed, the temperature gradient from the floor to the ceiling was lower with high speed than with low speed operation of the unit.

While the closing of the vents usually resulted in a 1 deg higher temperature at the ceiling, the resulting difference in the gradient between the floor line and the 30-in. level was usually smaller, and probably not significant. In other words, the closing of the vent opening did not unduly affect the temperature gradient in the occupied portion of the room; neither did it give a very significant rise in the ceiling temperature. The thermometers distributed throughout the room at the level of the tops of the desks showed no significant variation in temperature correlating with the opening or closing of the vents.

Observation was also made of the effect of the high pressure within the room on the operation of the doors leading to the corridor. Since the doors all opened outward, there was no tendency for them to slam in closing. There was a noticeable tendency for the pressure to force the door quickly open when the latch was released; however, not enough to snatch the door away from a person opening it. With the highest pressure observed in the rooms, the door when unfastened and released did not open with sufficient speed to hit the corridor wall. Usually, a door so released opened to about the three-quarter position before stopping.

In order to offer some evidence of the effect which a corridor vent opening either under or in the door would have, a few tests were made in which the pressure drop and air delivery were observed with the vent closed, and with the door opened various distances. The results

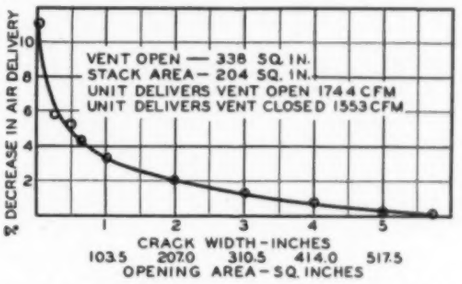
VENT OPEN — 338 SQ. IN.
STACK AREA – 204 SQ. IN.
UNIT DELIVERS VENT OPEN 1744 CFM
UNIT DELIVERS VENT CLOSED 1553 CFM
% DECREASE IN AIR DELIVERY
CRACK WIDTH – INCHES
103.5 207.0 310.5 414.0 517.5
OPENING AREA – SQ. INCHES

Fig. 3—Relation between door opening and the percentage reduction in air delivery to the room with vent closed, from the air delivery for the same room with the vent open and the door closed

of one of these tests are plotted in Fig. 3, showing that when the door was opened enough to allow a 2-in. crack the reduction from normal open vent air delivery was only 2 per cent.

Summary

1. The study, made in the 20 rooms of the Woodlawn school and in the 16 rooms of the Shaler School, indicates that, with normal unit ventilator operation and with all windows and doors closed, the closing of the vent opening decreased the volume of air delivery to the room by the unit ventilator from 1.7 to 25.9 per cent of the delivery with the vent open. The average reduction in air delivery was found to be 10.5 per cent for all rooms. This reduction in air delivery shows no consistent relationship with outside temperature, window area, or other room conditions, but seemed to depend more upon individual room characteristics.

2. The reduction in air delivery resulting from closed vents with low speed operation of the unit ventilators could be more than offset by an increase of the unit ventilator speed from low to intermediate.

3. Closing the vent openings usually resulted in a greater temperature gradient from the floor to the ceiling, and a higher temperature of approximately 1 deg at the ceiling. While the closing of the vent openings resulted in a slightly lower floor temperature for the same temperature at the 30-in. level, the drop in temperature was not great.

4. Closing the vent openings did not result in a greater temperature variation throughout the room at the 30-in. level in either an occupied or an unoccupied room, indicating equally good air distribution throughout the room with or without vent openings.

5. For the particular rooms studied in which all doors opened outward, no slamming or undesirable operation of the doors resulted from the pressure in the room when the vent openings were closed.

Acknowledgment

Acknowledgment is due to the officers and management of the Woodlawn Avenue School in Munhall and of the Shaler High School for their valuable cooperation in making the study a success.

Characteristics of Registers and Grilles

By **J. H. Van Alsburg*** ***(MEMBER)***
Holland, Mich.

DURING the last few years when rapid progress has been made in the air conditioning industry, emphasis has been placed upon those phases of the installation which seemed to be most important with the result that little attention was paid to the effect which the registers or grilles have on the performance of the system. Now it is apparent that registers and grilles directly affect the system in the following respects: 1. Noise, 2. Resistance, 3. Volume, 4. Flow, 5. Appearance.

An attempt will be made in this paper to outline the latest information available regarding the effect of registers and grilles on these five characteristics. This information is based on the results of many tests carried on since 1922. Several types of grilles are discussed, but no attempt to favor any particular manufacturer's design is intended, nor is any pretense made that the information given is final and complete. Much remains to be done on this subject and it is hoped that this paper will serve to stimulate further research and investigation.

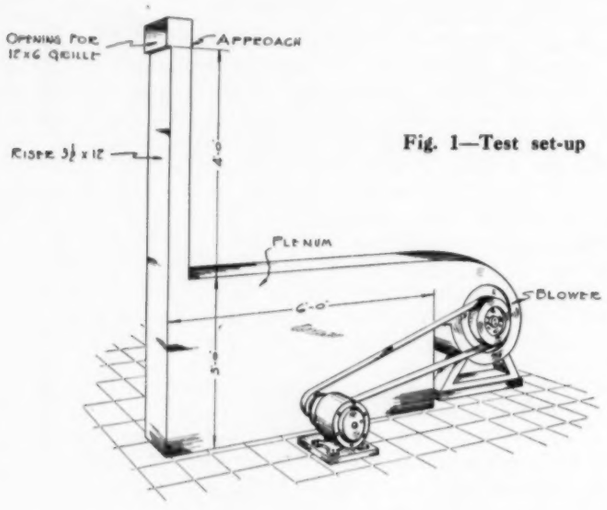

Fig. 1—Test set-up

At this point it is desirable to define the terms used in this paper. A grille is primarily a grating, used to conceal or decorate an opening through which air passes. A grille has no provision for controlling air volume. A register is the combination of a grille and some means for regulating air flow. A supply grille is one which admits air *into* a room or other enclosed space. A recirculating grille is one through which air is withdrawn from the room. Unless otherwise stated, the information given in this paper applies to supply grilles.

*Engr., Hart & Cooley Mfg. Co.

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Toronto, Ont., Can., June, 1935.

Test Apparatus

A room approximately 40x20x12 ft was used as a test laboratory. The testing apparatus, as shown in Fig. 1 consists of a standard blower, discharging a volume of air into a horizontal plenum chamber. From this chamber the air passes into a vertical duct, which makes a right angle expanding approach to the grille to be tested.

These tests were made with typical grilles of standard manufacture, all size 12x6, as shown in Fig. 2.

Smoke bombs were used to determine the path of the air stream and a standard 4 in. K. & E. anemometer, which was recently calibrated, was used for all velocity readings. In making the velocity readings at the register to determine the average velocity, the grille was blocked off in squares with chalk and one minute readings were taken of each block to determine an average for the total area.

In checking the velocity of the air away from the grille to determine the path of the air stream, the anemometer was used as described under Methods of Testing. A pitot tube was used with a Hays manometer for making all pressure readings, which were taken in the vertical riser above the plenum chamber, midway between the plenum chamber and the approach. These readings were taken by making a traverse to establish an average for the pressure at this point.

No suitable test apparatus was available for determining the noise level, and the blower, being in the test room near the grille, made it difficult to determine the cause of the noise. Therefore in the absence of suit-

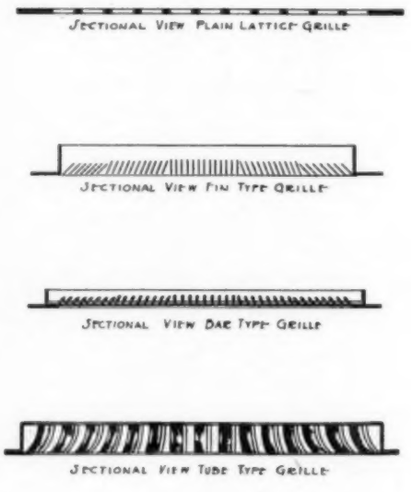
SECTIONAL VIEW PLAIN LATTICE GRILLE
SECTIONAL VIEW FIN TYPE GRILLE
SECTIONAL VIEW BAR TYPE GRILLE
SECTIONAL VIEW TUBE TYPE GRILLE

Fig. 2—Grilles tested

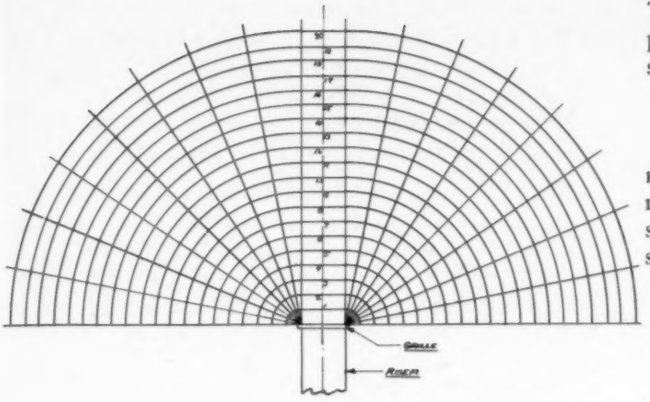

Fig. 3—Floor layout

able noise measuring devices, noise was determined by the hearing of several individuals assisting in this test.

Method of Testing

Lines were drawn on the test room floor as shown by Fig. 3, to serve as guides in taking velocity readings. Readings were taken at all intersections of these lines at 4 in. intervals above and below the center line of the grille at as high or as low a level as required to record the entire stream. No attempt was made to record velocities below 50 fpm.

Except where otherwise specified on the figures shown, the air temperature is room temperature of 70 deg. All grille areas were based on the Davies Formula, which is as follows for registers:

$$\text{Cfm} = CV \frac{A + a}{2}$$

and for this equation CV is a correction factor to be used for various velocities and anemometers of different sizes, A is the gross area of the grille and a is the net area of the opening through the grille, which is divided by 2 to establish the average or effective area. This formula has been thoroughly covered by papers[1] presented before the Society on three different occasions.

Noise

As mentioned before, suitable apparatus for accurately determining the cause of noise and its level was not available. The noise level for grilles has been considered 35 decibels but this does not take into consideration the pitch or frequency of the noise and this suggests further research be conducted to determine noise and that improvements be made in the present noise level determination equipment. Even without suitable apparatus certain results were obvious from the tests made and are herein mentioned.

In the first place the design and construction of the ducts, particularly the approach, have much more effect on the noise level than the grilles. A velocity up to 1500 ft can be used without air noise with practically any type of grille, using a standard approach, and by standard approach reference is made to a right angle turn between the duct and the grille with a change in dimension so the perimeter of the grille flange is larger than the perimeter of the duct, commonly called a riser, to allow slower outlet velocity. It is very difficult to eliminate noise in an air conditioning system with a duct velocity of over 2000 ft, which would be necessary if a velocity of 1500 ft were recorded at the grille. A velocity of 1700 ft can be used with perforated grilles, provided the fret work of the grille is not over ¼ in. wide. A

[1]Measurement of the Flow of Air Through Registers and Grilles, L. E. Davies, A.S.H.V.E. Transactions, Vol. 36, 1930; Vol. 37, 1931; A.S.H.V.E. Journal *(Heating, Piping and Air Conditioning)*, Sept. 1933.

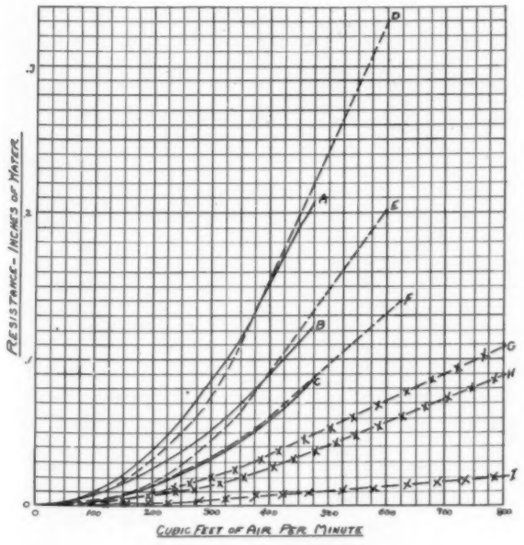

Fig. 4—Grille resistance

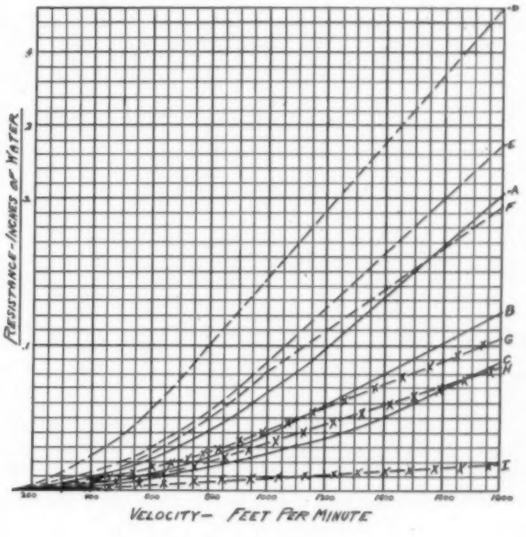

Fig. 5—Grille resistance

Symbols Used—Figs. 4 and 5

A—Perforated grille and duct
B—Perforated grille only
C—Duct only
D—Fin, bar or tube grilles and duct
E—Fin, bar or tube grilles only
F—Duct only
G—Tube grille, turning blades and duct
H—Tube grille and turning blades
I—Turning blades and duct

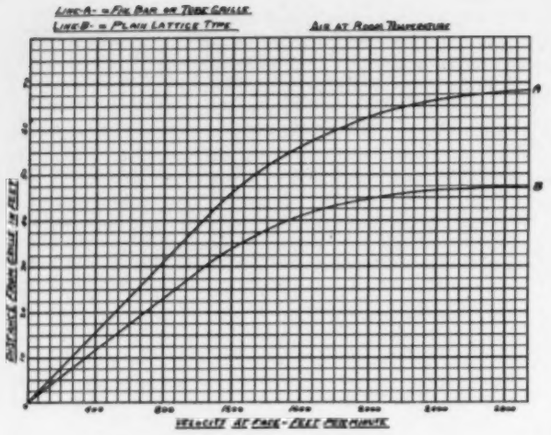
LINE A - FIN BAR OR TUBE GRILLE
LINE B - PLAIN LATTICE TYPE
AIR AT ROOM TEMPERATURE
DISTANCE FROM GRILLE IN FEET
VELOCITY AT FACE - FEET PER MINUTE

Fig. 6—Linear carry of air stream

velocity of 1500 ft can be used with a fin, tube or bar type grille without causing objectionable noise if the rear surface is flush instead of indented.

Much of the noise caused by the approach can be reduced by the use of turning blades, which allow an increase of 300 ft for the velocities mentioned, without increasing the noise caused by the grille. A properly designed combined approach, turning blades and grille in one unit has been constructed that permits velocities as high as 3500 ft without objectionable noise because the air turbulence in the approach and grille was eliminated.

Resistance

Figs. 4 and 5 show the resistance of various types of grilles, and of the duct only, based on cubic feet of air per minute and velocity in feet per minute, respectively.

All grilles used for the tests were 12x6 in., the construction of the grilles being shown in Fig. 2.

The Figs. 4 and 5 indicate that the resistance caused by the grilles will never exceed 10 per cent of the total resistance of the system, and that therefore grille resistance is of relatively small importance.

Volume

A change in the net free area of a grille does not have a corresponding effect on volume. For example, a 10 per cent reduction in the net area will reduce the volume approximately only 5 per cent provided the net area of the grille remains over 50 per cent.

Air Flow

By air flow is meant the distribution of incoming air into the room. This involves the distance the air travels, and the direction and shape of the air stream. It is obvious that the correct distribution of the incoming air is an important factor in the comfort of the occupants of the room and it is perhaps in connection with air flow that grilles assume the greatest importance. It is also in connection with air flow that the performance of different types of grilles varies the most.

There is no one type of grille which is suitable for all conditions. Much depends on the location of the grille, size of the room, velocities used, temperature of the incoming air and other factors. The characteristics of various types of grilles will be explained in order to assist in selecting the proper type to be used under whatever conditions exist on the installation.

The length of the air stream is governed primarily by the velocity of the air; secondly, by the type of grille; and thirdly, by the proportions of the grille. Fig. 6 shows the air carry for two types of grilles of the same size at various velocities.

Fig. 7 shows the air carry for two grilles of the same type and area but of different proportions.

The results shown in Fig. 7 indicate that the air will travel further with a grille having a smaller perimeter than one having a large perimeter, other conditions being the same.

The direction and shape of the air stream is very materially affected by the type of grille and also by the nature of the approach. If it is desired to project the air on a horizontal plane, it is necessary to either use turning blades in the approach or else use a grille having horizontal bars or fins of sufficient depth to guide the air horizontally. The air can be readily directed to

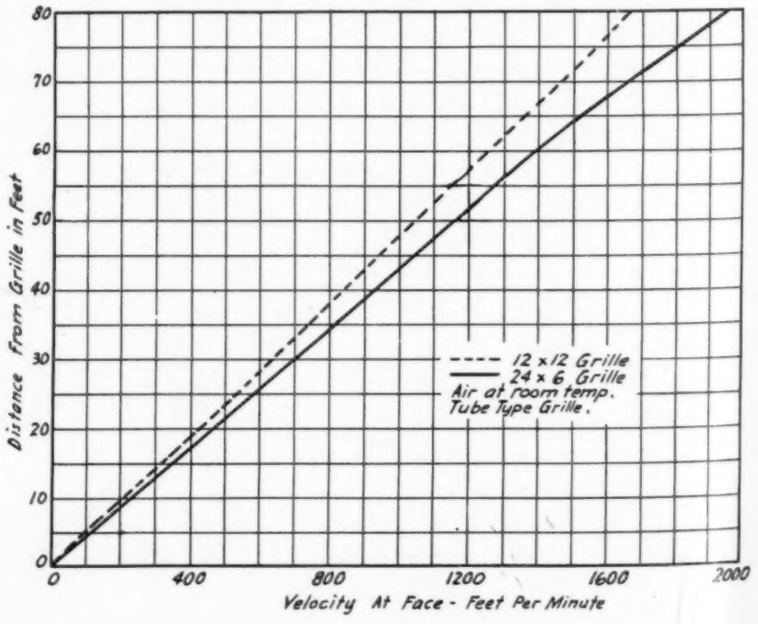

Fig. 7—Linear carry of air stream

the left or right by means of the grille, provided that the bars or fins of the grille are sufficiently deep. Fig. 8 shows the air flow with various types of grilles.

It will be noted that the results shown in Fig. 8 are based on the air leaving the grille being at the same temperature as the room air. This was done in order to isolate the effect of the grille from all other factors. In actual use the incoming air is almost always at a different temperature than that of the room air. Fig. 9 shows the effect which the temperature differential has on the rise or fall of the air at various velocities.

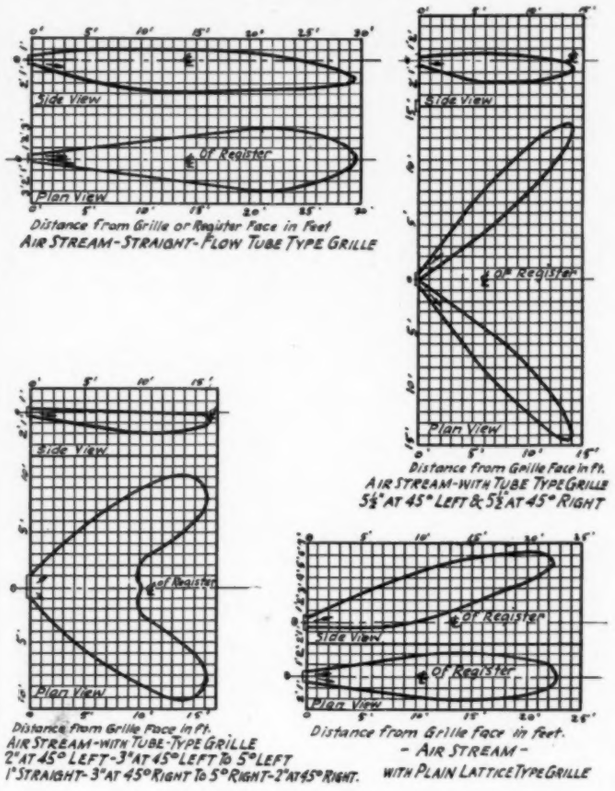
Side View
Plan View
℄ of Register
Distance from Grille or Register Face in Feet
AIR STREAM-STRAIGHT-FLOW TUBE TYPE GRILLE
Distance from Grille Face in Ft.
AIR STREAM-WITH TUBE TYPE GRILLE
5½° AT 45° LEFT & 5½° AT 45° RIGHT
Distance from Grille Face in Ft.
AIR STREAM-WITH TUBE-TYPE GRILLE
2° AT 45° LEFT-3° AT 45° LEFT TO 5° LEFT
1° STRAIGHT-3° AT 45° RIGHT TO 5° RIGHT-2° AT 45° RIGHT.
Distance from Grille Face in Feet.
- AIR STREAM -
WITH PLAIN LATTICE TYPE GRILLE

Fig. 8—Air flow at room temperatures

From the charts shown on Figs. 6, 7, 8, and 9 it is obvious that by using the proper velocity with the proper type of grille, the air flow can be controlled as desired with considerable accuracy.

Another factor entering into the distribution of the air in a room is the effect which the incoming air has on the air already in the room. This is called the aspiration factor. Information regarding this has not been sufficiently developed to be presented at this time. It is a subject worthy of much additional study.

Appearance

What constitutes an attractive looking grille is a matter of opinion. Many attempts have been made to make grilles pleasing to the eye and in other cases attempts have been made to make grilles as inconspicuous as possible. At the present time many developments are under way to combine grilles and lighting fixtures so they will furnish direct and indirect lighting and to carry the required amount of air into a space, so designed that they are artistically proportioned and enhance the appearance of any room. It is important that it be impossible to see the duct or approach immediately back of the grille and that the finish harmonizes with the room. They should, of course, be neat and trim looking and installed, where possible, in a frame so they will not streak the walls, which can be accomplished by setting the grille in a frame so the front of the grille is flush with the wall, which causes the air that leaks between the grille and the frame to travel at right angles to the surface of the wall so it will not streak as it often does when the air travels parallel to the wall surface. Installation of grilles is very important and the architect or engineer responsible for the job should insist on this.

Recirculating Air Grilles

Nothing which has been previously said in this paper applies to recirculating air grilles.

Tests have been made which indicate that high velocities may be used through recirculating air grilles without showing an appreciable air movement a few feet away from the grille. With a velocity of 1000 ft through a 12x12 in. grille, for example, the velocity of the air 16 in. away from the grille is less than 50 ft and with a grille 24x24 in. and a velocity of 1000 ft, this velocity is reduced to 50 ft between 24 and 30 in. away from the grille.

Although much is already known regarding the characteristics of grilles, there is ample opportunity for additional research in this field, particularly when the effect various types of grilles and their location have on the air distribution within a room is considered.

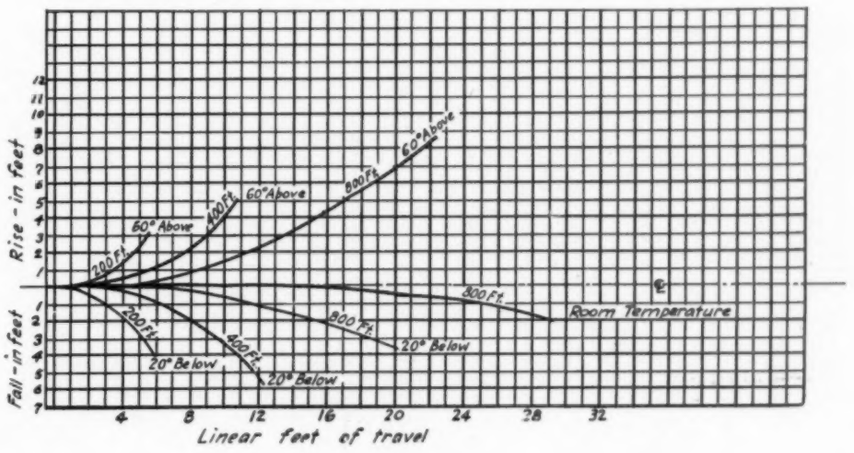

Fig. 9—Air stream rise and fall at various velocities and temperatures

H. H. Angus
Reception

H. B. Jenney
Ladies

Mrs. E. H. Gurney
Ladies

W. P. Boddington
Entertainment

Thomas McDonald
Banquet

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M. W. Shears
Transportation

Toronto in June

OFFICE OF
THE DEPUTY MINISTER OF IMMIGRATION
AND COLONIZATION
OTTAWA, CANADA.

May 10th, 1935.

Dear Mr. Hutchinson:-

I have learned with much interest that the American Society of Heating and Ventilating Engineers will hold a convention at Toronto, June 17 - 19 The Department of Immigration and Colonization of the Canadian Government is charged with the duties connected with the admittance of tourists and others into the Dominion, and I am writing this line to assure you of our co-operation in any way we can in making your visit to Canada a success.

It is the desire and policy of the Canadian Government to eliminate as far as possible any delay or inconvenience to bona fide tourists entering Canada from the United States. Only the duty of guarding against the admittance, in the guise of tourists, of persons not legally admissible, necessitates such simple formalities as are required. In brief, citizens of the United States entering Canada as tourists may expect no inconvenience whatever. Persons who are not citizens of the United States should carry evidence that they are legally resident in your country and they should be in the position to satisfy the Canadian Officer at the International Boundary that they will have no difficulty in returning to the United States. Tourists' automobiles are admitted without charge and may be driven for pleasure in Canada under their State licenses for a period of sixty days, which period may be extended upon application.

I have thought it well to place these facts before you so that no one from the United States may be deterred from coming by any fear of embarrassment at the border, and it may be that you will wish to make this fact as widely known as possible through such means as are at your command.

I am having instructions sent to the Canadian Inspectors of Immigration at the border to ensure that every courtesy consistent with the regulations is extended to these visitors.

May I express the personal hope that your convention will be a great success and that every experience of the visitors from the United States will tend toward still warmer friendship and a clearer understanding between our two countries?

Yours very truly,

J. Maglademy

Deputy Minister.

MEMBERS of the A.S.H.V.E. will find Toronto delightful in June when the Semi-Annual Meeting of the Society will be held in this great Canadian metropolis with members of the Ontario Chapter acting as hosts. A program of unusual interest has been prepared for the three day meeting June 17-19. Technical papers on subjects that are of utmost importance to the profession and industry will be discussed and the leisure hours will be particularly enjoyable as a full program of social events has been scheduled for both members and ladies.

The members of the Committee on Arrangements are presented at this time. Under the leadership of Messrs. Gurney and Anthes every phase of meeting activity will be handled by an enthusiastic and capable sub-committee. Their efforts will be exclusively devoted to making the stay of visiting members and ladies pleasant and enjoyable.

Members entering Canada by rail or by motor will find the customs formalities very brief and officials will give courteous and helpful service. Toronto is easily accessible from all parts of the United States and Canada by rail, and through-car service is available from principal centers of population. Reduced railway fares have been granted by all railroads and the round-trip can be made under the Identification Certificate Plan for one and one-third fares. Identification certificates have been sent to all members of the Society by the Secretary so that they may be presented to local ticket agents for purchase of round-trip tickets to Toronto. One Identification Certificate can be used by a member and his entire family and will be honored over any authorized route for the going trip and for return by an alternate route if desired. The route must be specified at the time of purchasing tickets. At Toronto all tickets must be stamped at the railroad station before starting the return trip.

Those who motor from the middle west may enter Canada via Detroit, while those further east may go through Buffalo, Niagara Falls, or Lewiston, and New Englanders have a choice of routes through Ogdensburg, Lewiston, Buffalo, and Niagara Falls, N. Y. Automobile clubs, gasoline and oil companies can furnish the latest information on road conditions and up-to-date maps.

The headquarters hotel, The Royal York, where all meetings will be held is the largest hotel in the British Empire. Reservation cards showing special convention rates for the meeting have been mailed to all members. Visitors will find that Toronto has a charm that is unescapable and some of the salient facts about Canada's largest city should be noted by members when planning their trip. For its population which exceeds 850,000, Toronto has a large residential section, all dwellings being built of either stone or brick. The streets are tree lined and unusually well lighted. Toronto is the capital of the province of Ontario and is the focal point of the world's two largest railway systems. Toronto Islands form the largest recreation ground in the world and the Royal Canadian Yacht Club is the largest fresh water club of its kind. There are 74 parks in Toronto and 56 equipped play grounds. The city has 26 eighteen-hole golf courses, 2,400 manufacturing establishments, and more than 300 subsidiary plants of United States and British industries.

How many know that Toronto is distinguished as the birthplace of Mary Pickford; that it is the best lighted city in America; that it has the largest heated swimming pool in the world; that it has a university attended by 10,000 students, and has the cheapest electric light and power in the world?

For those who wish to make the Semi-Annual Meeting of the Society a combined business and pleasure trip, several side trips can be arranged with little extra cost when reduced fare round-trip tickets are purchased. Members living in the Great Lakes area can plan a delightful boat trip or arrangements can be made to visit Montreal, Ottawa, Quebec, the Thousand Islands of the St. Lawrence, or the popular Muskoka Lakes and the Lake of Bays.

Don't forget the cordial invitation of the Ontario Chapter to come to Toronto for the Semi-Annual Meeting 1935—June 17-19 are the dates. The Royal York Hotel is meeting headquarters.

Provincial Government Buildings

PROGRAM

SEMI-ANNUAL MEETING 1935

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Royal York Hotel, Toronto, Ont., Can.

June 17-19, 1935

(All Events Scheduled on Daylight Saving Time)

Sunday, June 16, 1935

6:30 p.m. Dinner and Meeting of the Council.

Monday, June 17, 1935

9:00 a.m. Registration.

10:00 a.m. Greeting.
Response by President Howatt.
Amendments to By-Laws.
Technical Papers:

Characteristics of Registers and Grilles, by J. H. Van Alsburg.

A Study of Classroom Ventilation:

Part I—Classroom Odors with Reduced Outside Air Supply, by F. C. Houghten, H. H. Trimble, Carl Gutberlet, and M. F. Lichtenfels.

Part II—Air Supply to Classrooms in Relation to Vent Flue Openings, by F. C. Houghten, Carl Gutberlet, and M. F. Lichtenfels.

Part III—Classroom Drafts in Relation to Entering Air Stream Temperature, by F. C. Houghten, H. H. Trimble, Carl Gutberlet, and M. F. Lichtenfels.

1:00 p.m. Cars leave hotel for Weston Golf Club.

1:30 p.m. Meeting of the F. Paul Anderson Award Committee, G. L. Larson, Chairman.

1:30 p.m. Meeting of the Committee on Research, A. P. Kratz, Chairman.

1:30 p.m. 18-hole Handicap Golf Tournament for Research Cup.

3:00 p.m. Sight-seeing trip for ladies and members through City of Toronto and visit to Granite Club, returning to the hotel.

6:45 p.m. Buses leave hotel for the Old Mill to join the golfers.

7:30 p.m. Informal dinner followed by dancing for members and ladies at the Old Mill.

Tuesday, June 18, 1935

9:30 a.m. Technical Papers:

Heat Absorbing Glass Windows, by W. W. Shaver.

Cooling and Air Conditioning in an Ale Brewery, by C. P. Creighton and F. J. Friedman.

An All Electric Heating, Cooling and Air Conditioning System, by Philip Sporn and D. W. McLenegan.

A Rational Heat Gain Method for the Determination of Air Conditioning Cooling Loads, by F. H. Faust, F. O. Urban, and L. Levine.

10:30 a.m. Inspection of Art Gallery and Ontario Museum by the ladies.

12:30 p.m. Luncheon Meeting of the Committee on Ventilation Standards, W. H. Driscoll, Chairman.

1:30 p.m. Meeting of the Guide Publication Committee, G. L. Larson, Chairman.

1:30 p.m. Informal golf matches for members.

2:00 p.m. Boat leaves wharf for Royal Canadian Yacht Club, where the ladies will enjoy a Bridge and Tea.

2:30 p.m. Visit and Inspection of Research Foundation. Boat trip and inspection of harbor development for men.

7:30 p.m. Dinner Dance for members and ladies at the Royal York Hotel.

Wednesday, June 19, 1935

9:30 a.m. Technical Papers:

Oil Burning in Residences, by D. W. Nelson.

The Dust Problem in Air Conditioning, by F. B. Rowley.

Chicago Standards for Certified Air Conditioning, by S. R. Lewis.

Resolutions.

Adjournment.

11:00 a.m. Shopping tour of Toronto stores for ladies.

12:30 p.m. Luncheon meeting of the Nominating Committee.

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings, be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting:

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the same of tickets for group features be discouraged.

6—That the raising of Funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter, or local members, be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

PRESIDENT'S MESSAGE TO MEMBERS

THE GUIDE

If by its works it shall be known, the A.S.H.V.E. can well afford to be judged by The GUIDE. It is a work of our Society of which every member may well be proud. It is the more remarkable because the preparation of the material that goes into it has fallen upon members who have given so liberally of their time and talent year after year.

The GUIDE was founded in 1922 and from its very beginning has been dedicated to the advancement of the arts and profession of Heating, Ventilating and Air Conditioning. The founders named it well, for in the thirteen years of its existence it has indeed proven to be a guide in every sense of the word. There is no book published that so clearly and completely explains present practice or which so quickly presents the results of recent research. Engineers make use of its tables in their plant design and manufacturers in their equipment performance guarantees.

Every engineer, manufacturer and contractor engaged in Heating, Ventilating or Air Conditioning work should possess a copy of The 1935 A.S.H.V.E. GUIDE and make use of it. Every member of our Society should refer to it as the authority in its field.

John Howatt President,

June 1, 1935. American Society of Heating and Ventilating Engineers.

John W. James Joins A. S. H. V. E. Staff

On May 1, Mr. John W. James commenced his duties at the headquarters office of the Society and will be engaged in those engineering phases of the Society's activities connected with the editorial work of its official publications, in the development of codes, and in special technical committee work.

John W. James

Mr. James enters his new work with a background of experience, as test engineer in the Air Conditioning Division of General Electric Co., Schenectady, as a Research Engineer in the Department of Mechanical Engineering at the University of Wisconsin, Madison, Wis., and in the design of mechanical systems for public and private buildings for G. E. Reed, consulting engineer, Portland, Ore.

Although born in Brookville, Ind., Mr. James followed Horace Greeley's advice at the tender age of five and went with his parents to Portland, Ore., where he received his elementary school training, graduated from Benson Polytechnic High School in 1924, after which he attended the Oregon State College and received the degree of B.S. in Mechanical Engineering in 1928. After graduation, he spent four years in designing mechanical systems for buildings, one of which was the new United States Court House recently completed in Portland. In 1932, the Board of Regents at the University of Wisconsin selected Mr. James as a Research Fellow in the Department of Mechanical Engineering and this two year appointment permitted him to complete graduate work for a Master of Science degree under the direction of Prof. G. L. Larson.

Mr. James is a Registered Professional Engineer in the State of Oregon, holds membership in A.S.M.E., and A.S.H.V.E., and is a member of the Phi Sigma Kappa, national social fraternity, and Sigma Xi, national honorary scientific society.

Institution of Heating and Ventilating Engineers Meeting, June 24-26

The Summer Meeting of the *Institution of Heating and Ventilating Engineers* will be held at the Felix Hotel, Felixstowe, England, June 24, 25 and 26.

The program, which has been issued by H. B. Watt, Secretary, announces a Council meeting on Monday, June 24, and a special meeting on Tuesday when a paper by W. L. Gee will be given on Fan Characteristics. In the afternoon golf, lawn tennis, bowling and other sports will be arranged. A reception at the Felix Hotel will precede the banquet and dance, to be held Tuesday evening.

On Wednesday, June 26, a circular motor drive will be enjoyed, followed by luncheon and tea in the afternoon at the invitation of the president, W. E. Fretwell.

Headquarters of the *Institution of Heating and Ventilating Engineers* are at 12 Russell Square, London.

Philadelphia Chapter's Tribute to Stewart A. Jellett

The Philadelphia Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS learns with profound sorrow of the death, on April 5, 1935, of its beloved fellow-member, Stewart A. Jellett.

The Philadelphia Chapter has, in the death of Mr. Jellett, lost one of its most valued members, whose loyal service has left a deep impression on the history and development of the Chapter, whose outstanding ability has earned him a national reputation and whose personal influence has helped the members of the Chapter in their work and professional advancement.

The Life of Stewart A. Jellett, Sr.

The City of Philadelphia has taken its place in the march of progress by influential representatives in every civic and social movement of State and National character, so it was but fitting that it should have its Stewart A. Jellett, who along with that small group of men met in 1894 and organized the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Mr. Jellett thereby becoming one of the Charter Members.

Full realization was impossible for these earnest, ambitious and unselfish men who gave their time and energy, not alone for personal gain, but rather from an exchange of ideas, experience, and cooperation. How well they builded, Mr. Jellett was one of the few who lived long enough to realize. To those of us who have received this rich heritage it might well be said:—

From which unselfish start
Let those who follow ne'er depart.

Stewart A. Jellett was born March 7, 1862. He was indentured at the age of 17 to learn the trade of engine turning on watch cases. Upon the termination of this apprenticeship and but two years intervening, he launched into the field of ventilation and heating, and from then on until illness prevented, he was a recognized leader in his chosen profession.

From 1885 to 1887 he was engineer for the Philadelphia Exhaust Ventilator Co., during which time he designed and supervised construction of systems of drying various classes of materials. From 1887 to 1889 he was a partner in the above mentioned company. During this period he designed and supervised the installation of a complete mechanical ventilation plant for the Cruiser Yorktown, which was probably the first mechanically ventilated ship in the United States Navy. He also designed one of the first of the down feed systems of exhaust steam radiator supply piping.

From 1889 to 1912 he was engineer, vice-president and treasurer of Francis Brothers and Jellett. During this period he was in charge of design and installation of numerous heating, ventilating and electric generating plants.

From 1912 until his death he was president of the Stewart A. Jellett Co., which firm established through thrift, honesty of purpose and ability, a record in the field of their endeavor second to none.

Mr. Jellett was a pioneer in the field of fire prevention. He was one of the organizers of the Fire Prevention Committee of the Chamber of Commerce, acting as chairman of this Committee from 1920 to 1925. At this latter date he was elected to the Board of Directors of the Chamber of Commerce and served until 1934, when continued illness prompted his resignation.

Mr. Jellett was the second president of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, serving in 1895. From that time on until within a few years of his death, his was an active and impelling interest in the affairs of the Society and the Philadelphia Chapter. His recent illness alone prevented him from attending the meeting of these two bodies.

Mr. Jellett was further recognized by the Society by being elected an Honorary Member.

In 1901 he was president of the *Heating and Piping Contractors National Association.*

He was an organizer and first president of the *Germantown and Chestnut Hill Improvement Association.*

He was a member of the Union League, Manufacturers' and Bankers' Club, and the Philadelphia Cricket Club.

Stewart A. Jellett died Friday, April 5, 1935, and was buried Monday, April 8, 1935, in Ivy Hill Cemetery.

Mr. Jellett is survived by his wife, Catherine, three sons, Stewart A. Jr., Roland T., and Joseph M., and a daughter, Theodorea.

"To every man upon this earth
Death cometh soon or late,
And how can man die better
Than facing fearful odds,
For the ashes of his fathers
And the temples of his gods."—*Macaulay.*

Be It Resolved That the Philadelphia Chapter extend to his family its deepest sympathy in their bereavement and sorrow; and as an acknowledgment of his loyalty, brilliant leadership, kindly sympathy, ready helpfulness and professional ability, it is directed that this Resolution of condolence and regret be spread upon the minutes of the Chapter, and a copy of this Resolution be sent to his family.

J. D. Cassell, *Chairman*
F. D. Mensing
H. P. Gant

Local Chapter Reports

Kansas City

April 8, 1935. The Kansas City Chapter met at 6:00 p.m. at the Newbern Hotel with an attendance of 24 members and 10 guests. Pres. L. A. Stephenson called the meeting to order and the minutes of the previous meeting were read and approved.

Pres. Stephenson appointed the following Committee for Standardization of Air Conditioning: W. E. Gillham, *Chairman;* Henry Nottberg, N. W. Downes, F. V. Becklean, and Carl Clegg. Mr. Gillham asked the Chapter for suggestions on the work to be accomplished.

E. K. Campbell, chairman of the Membership Commitee, reported receipt of the application of a new member.

The Chapter discussed plans for the annual June meeting and after discussion, the vote decided in favor of a social meeting. President Stephenson appointed the following committee to be in charge of the party: J. M. Arthur, Chairman; G. L. Bliss, David Caleb, E. K. Campbell, Jr., and C. A. Flarsheim.

A motion was made to assess the treasury of the Chapter for $100.00 and that a charge of $1.00 per ticket be made for the party.

Secy. L. R. Chase read Pres. John Howatt's letter to the Chapter.

An announcement was made of the plans of the Ontario Chapter for the Semi-Annual Meeting of the Society to be held in Toronto in June.

President Stephenson introduced the speaker of the evening, N. D. Adams, who gave a very interesting discussion of the application of air conditioning for the treatment of various diseases. Mr. Adams' talk was followed by slides and a description of the construction of the Franklin Heating Station, Rochester, Minn.

Mr. Adams invited the Kansas City Chapter to attend the joint

meeting of the Minnesota, Wisconsin, and Illinois Chapters to be held at Rochester on June 7.

Ontario

May 13, 1935. The annual meeting of the Ontario Chapter was held at the Royal York Hotel when 43 members were present. Dinner was served at 6:30 p.m.

Pres. W. R. Blackhall called upon Secy. H. R. Roth to read the minutes of the two preceding meetings and, upon motion, the minutes were accepted as read.

M. W. Shears reported for the Attendance Committee that the average attendance at meetings during the past year had been 45.

Thomas McDonald of the Membership Committee stated that 22 new members had been obtained during the past year and that two membership applications were pending.

The treasurer reported that the financial standing on May 1, 1935 was a balance of $201.88 in the Chapter's funds and a balance of $70.53 in the University of Toronto award fund.

E. T. Whittall, Chairman of the Auditors, read their report, and a copy will be sent to each member.

M. B. Watson discussed a motion to amend the Constitution which will be brought up at the next regular meeting.

Election of officers was held and the following members were unanimously elected:

President—M. W. Shears.
Vice-President—Thomas McDonald.
Secretary-Treasurer—H. R. Roth.
Board of Governors—H. D. Henion, G. A. Playfair, H. B. Jenney, W. R. Blackhall.

W. P. Boddington made a motion, which was seconded by D. O. Price, that the Chapter extend to Mr. Blackhall its deep appreciation of his splendid service during the year.

E. H. Gurney, Chairman of the Committee on Arrangements for the Society's Semi-Annual Meeting, spoke of plans which had been made and called upon each committee chairman to outline the respective activities of his committee and to announce the members who would serve with him.

Installation of the newly elected officers was made and President Shears told the members that the University of Toronto award of the Ontario Chapter had expired the five-year period arranged for. Mr. Watson moved that the Secretary notify the bursar of the University that the award was being withdrawn and that the balance of the funds be put in the treasury of the Chapter. This motion was seconded by O. L. Maddux and passed.

The meeting then adjourned.

Pacific Northwest

April 23, 1935. The Pacific Northwest Chapter members and guests met at the Hungerford Hotel, Seattle, Wash., and Pres. A. L. Pollard presided with an attendance of 20.

The minutes of the March meeting were read and approved.

A telegram sent to Pres. John Howatt of the A.S.H.V.E., regarding Chapter representation at Annual Meetings of the Society, was read and the approval of the Chapter was expressed.

President Pollard announced the appointment of a Nominating Committee and stated that the Chapter officers for 1935-36 would be installed at the May meeting.

The guest speaker of the evening was C. A. Pangborn, who had recently returned from an air conditioning meeting at Schenectady, N. Y. Mr. Pangborn gave a talk that was well presented and of great interest to the Chapter. The use of a psychrometric chart in estimating heating and cooling loads, reverse cycle heating, and a method of assembling standard units in combinations to obtain desired results in central air conditioning systems, were described by the speaker. Of particular interest was the description of a multiple boiler central station heating installation, which was discussed at length, including the boiler hook-up, and the method of control for boilers and buildings.

The meeting adjourned at 10:00 p.m., according to the report of Secy. S. D. Peterson.

March 14, 1935. The Chapter was host to John Howatt, Chicago, Ill., President of the A.S.H.V.E., who was guest and speaker on this occasion. Preceding the meeting, a dinner was held at the Edmond Meany Hotel, attended by 40 members and guests, with A. L. Pollard, President of the Chapter, presiding.

Our Position Today was the subject of President Howatt's address. A resumé of conditions throughout the country; the need of definite standards of air conditioning; and the necessity for public education regarding air conditioning and public health were subjects well covered and ably presented by Mr. Howatt. The importance of the part of operating engineers in the successful operation of a mechanical installation was stressed and President Howatt urged that every effort be made to interest them in the Society and its activities.

The visit of President Howatt of the A.S.H.V.E. was greatly enjoyed and appreciated by the Chapter.

The meeting adjourned at 10:00 p.m.

Philadelphia

May 9, 1935. The regular monthly meeting of the Philadelphia Chapter was held at the Roxborough Country Club and was called to order by Pres. J. H. Hucker. Upon motion the minutes of the April meeting and the report of the treasurer were not read.

President Hucker called for nominations for the Nominating Committee. W. F. Smith presented the following names: F. D. Mensing, Chairman; W. P. Culbert, H. G. Black, L. C. Davidson and A. H. MacDade. Upon motion made and seconded the nominations were closed and Secy. H. H. Erickson was instructed to cast a ballot for their unanimous election.

The Summer Meeting of the Society to be held in Toronto, June 17, 18, and 19, was discussed by President Hucker.

Before presenting several awards to the successful members who had taken part in the golf tournament, A. C. Caldwell was thanked by President Hucker for his splendid work as chairman of the Meetings Committee.

The meeting then adjourned to allow for the festivities enjoyed by the members.

Pittsburgh

April 15, 1935. The meeting was called to order at 7:50 p.m. by Pres. L. B. Pittock in the auditorium of the U. S. Bureau of Mines. The minutes of the March meeting were read and approved with a change in wording requested by F. C. McIntosh.

Reports were given and M. L. Carr of the Program Committee described plans for an inspection trip through the Pittsburgh Testing Laboratories at the May meeting.

T. F. Rockwell reported on the financial condition of the Chapter.

R. B. Stanger read a letter from the Executive Committee of the *Affiliated Technical Societies,* stating operating plans for 1935-36. As Chairman of the Committee representing the Pittsburgh Chapter of the A.S.H.V.E., Mr. Stanger asked for authority to act on the several proposals contained in the report, and upon motion, authority was granted.

Secy. T. F. Rockwell read or made reference to a number of letters of general chapter interest. Included were letters from the headquarters office of the Society on THE GUIDE 1935 and the Semi-Annual Meeting in Toronto, June 17-19; an invitation to participate in the exposition of the *National Association of Power Engineers* to be held in Pittsburgh in August; and a Code of Air Conditioning Standards prepared by the *Chicago Association of Master Steamfitters* and allied organizations.

Mr. McIntosh read Pres. John Howatt's monthly letter to Chapters which dealt with membership. Mr. McIntosh, who is Chairman of the Membership Committee of the A.S.H.V.E., then discussed the growing interest in Southern cities in the formation of local chapters.

H. L. Moore, Chairman of the Committee appointed to study

national nominating methods, presented the following resolution which was signed by R. J. J. Tennant, E. C. Evans and Mr. Moore: That the Pittsburgh Chapter is in favor of the present method of selecting Chapter representatives and alternates to function as the Nominating Commitee of the A.S.H.V.E., the Pittsburgh Chapter suggests that the present requirements for certification of Chapter representatives and alternates to the Nominating Committee be strictly enforced and that the Secretary of the Society re-certify such appointees to the Chairman of the Nominating Committee at each meeting and that the Nominating Committee shall consist only of such appointees as are present at the committee meeting.

Mr. Moore moved the adoption of the resolution and the motion was carried.

It was moved by Mr. Evans that President Pittock take the necessary steps to secure from W. T. Jones, Past President of the Society, printed copies of his address on the value of membership in the A.S.H.V.E. The motion was carried.

A report of the Committee to Study the Proposed Code for Ventilation of School Buildings in Pennsylvania was read by G. S. McEllroy. After reading the complete report, each one of the Committee's recommendations was thoroughly discussed from the floor.

F. C. Houghten, who served as a member of the Commission which formulated the code, was called upon to explain the intent of the Commission on certain questions which were not clear.

With the exception of a few items, which were referred back to the committee for further study, it was the consensus of those present that the committee's report be approved.

It was moved by G. S. McEllroy and carried: That the Pennsylvania School Heating and Ventilating Commission is to be commended for the broad and comprehensive manner in which they have covered this matter in their first report, and that the members of the Pittsburgh Chapter of the A.S.H.V.E. extend to the Commission, both individually and as an organization their fullest cooperation in their work.

It was moved by Mr. Stanger that the Committee correlate its report with that of a similar committee of the Philadelphia Chapter before forwarding the report to the State authorities in Harrisburg. The motion was carried.

The meeting adjourned at 11:00 p.m.

St. Louis

April 2, 1935. After dinner the April meeting of the St. Louis Chapter was called to order by Pres. J. W. Cooper at the Rankin School and the minutes of the previous meeting were read and approved. Twenty members and guests attended the dinner, with a total of 36, including G. B. Rodenheiser's class, in the speaker's audience.

President Cooper read a letter from John Howatt, Chicago, Ill., president of the A.S.H.V.E., in appreciation of courtesies shown him on his recent visit to St. Louis, and also a letter from President Howatt on membership.

The appreciation of the Chapter for the opportunity of meeting at the Rankin School was expressed to Mr. Turner, who in turn thanked the Chapter for holding its meeting and also for its help on the Open Forum on Air Conditioning.

Secy. A. L. Walters reported for the treasurer a balance on hand of $397.68.

J. M. Foster, of the Membership Committee, introduced two new members who were present, V. E. Hugoniot and L. L. Hamig.

G. B. Rodenheiser gave the following report on the seven meetings of the Forum held January 14 to February 28: total attendance, 3,205; average attendance, 458; largest attendance, 620 at the first meeting; smallest attendance, 300 at the second meeting when the weather was very cold and severe. Mr. Rodenheiser stated that there was much favorable comment and a widespread demand for copies of papers.

The meeting was then turned over to G. W. F. Myers, chairman of the Program Committee, who introduced the speaker, H. W. Buschman. A chalk talk was given on Selling Air Conditioning.

After a rising vote of thanks to Mr. Buschman, the meeting adjourned.

Western New York

May 13, 1935. A dinner and meeting was held at the Tourraine Hotel with 38 members and guests present for dinner and 65 in attendance at the meeting, when it was called to order by Pres. W. E. Voisinet.

Joseph Davis outlined arrangements made by Ontario Chapter for the Society's Semi-Annual Meeting in June with the timely appeal that Western New York Chapter reciprocate with Ontario Chapter for the fine attendance of their members at the Annual Meeting in Buffalo in January. Plans were made to arrange group motoring parties to Toronto for the meeting and it was indicated that a sizable delegation will make the trip from Buffalo.

P. S. Hedley, Chairman of the Attendance Committee, thanked the members of his committee for their cooperation and work, which was evidenced by the good attendance at the May meeting.

M. C. Beman, a member of the Council of the Society, spoke on affairs of the A.S.H.V.E. This feature of the monthly meetings keeps the members informed on Society activities.

A motion was unanimously passed to draw $50.00 from the treasury to partly defray the expenses of Mr. Beman and President Voisinet in attending the meeting in Toronto.

With appropriate remarks, President Voisinet introduced the speaker of the evening, W. L. Fleisher, consulting engineer, New York, N. Y., whose subject was Research and Its Effect on the Material Requirements of Air Conditioning. In his preliminary remarks, Mr. Fleisher stressed the psychological appeal of air conditioning to the public and possibilities of the Society's research program. Mr. Fleisher also discussed summer cooling standards and made some suggestions for possible revisions of the Comfort Chart.

A very interesting informal discussion between Mr. Fleisher and L. A. Harding followed relative to the Comfort Chart, comfortable indoor conditions, means of attaining and maintaining them, and allied technical data. The rising vote of thanks which was given to Mr. Fleisher attested to the interest and educational value of his talk.

Secy. J. J. Landers reports that a golf meeting is planned for June in charge of the Entertainment Committee of which Mr. Davis is chairman.

Minnesota

May 18, 1935. A fitting climax to another successful year in the history of the Minnesota Chapter was the expression of the many members who attended the meeting in Rochester, Minn. N. D. Adams was host and chairman of the Arrangements Committee and Mrs. Adams was in charge of the Ladies Committee. The City of Rochester and the Mayo Clinic enthusiastically joined in to make the day one that will long be remembered and, according to the report of Secy. R. E. Backstrom, never before have the members and their guests been so delightfully entertained at their final yearly meeting and election of officers.

Some thirty couples, a number of individual members and their guests, and a group from the Illinois Chapter had lunch at the Rochester Country Club. At 2:30 p.m. the first of the golfers teed off and among the players was a foursome including Pres. John Howatt and two of the Society's Past Presidents, Dr. E. V. Hill and F. B. Rowley. The ladies, among whom was Mrs.

Howatt, were conducted through the Mayo Clinic and later attended tea at the home of Dr. and Mrs. H. S. Plummer.

Dinner was served at the Country Club, during which the music of the orchestra, violin solos, songs, and dancing were enjoyed. Mayor Moore extended a hearty welcome, citing many points of interest about Rochester, and C. E. Gausman, newly elected president of the Chapter, responded.

Following the banquet and entertainment, three distinguished doctors from the Mayo Clinic presented short talks of vital interest to heating, ventilating and air conditioning engineers. Dr. Walter Boothby, director of Metabolic Research, Mayo Clinic, discussed Dynamics of the Human Body. Dr. Charles Sheard, professor and director of Biophysical Research, Mayo Foundation, University of Minnesota, gave an illustrated talk on the Effects of Environment. The Effects of Environment on Disease was discussed by Dr. George Brown, consultant, Department of Neurology, Mayo Clinic.

It is easy to understand that discussion relating to the human body as a heat machine, the thermostatic controls in the body, and subjects whose thermostatic controls do not function properly, would be of unusual interest to engineers as well as to doctors. The need for correlation of thinking between the medical and engineering professions in striving to attain better air conditions for better health was made evident by the splendid talks. The Society can well be proud of its affiliation with the Mayo Clinic through its Technical Advisory Committee on Air Conditioning in the Treatment of Diseases.

After presentation of the awards for golf were made by A. J. Huch, the tables were cleared away and dancing was the order of the evening. Currency of the stage variety was used to liquidate bridge and poker debts. The hour was late when the homeward trek began and the vote was unanimous that Mr. Adams had been most successful in providing a day of good fellowship, education and interesting entertainment.

A short business meeting was held prior to the banquet and a report of the Nominating Committee was given by Chairman A. B. Algren. Upon motion of A. J. Huch, seconded by Albert Buenger, the Secretary was instructed to cast a unanimous vote for the candidates suggested by the Nominating Committee. The following officers were elected for the coming year:

President—C. E. Gausman
Vice-President—N. D. Adams
Secretary-Treasurer—R. E. Backstrom
Board of Governors—J. E. Swenson, H. M. Betts.

April 15, 1935. The meeting was called to order by Vice-Pres. C. E. Gausman and the minutes of the March meeting were read and approved. Fifty members and guests were present. The report of the Nominating Committee was given by Prof. A. B. Algren, chairman.

An extremely interesting and educational talk on the subject of Mechanical Refrigeration as Applied to Air Conditioning was given by H. H. McKinnies.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 24 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by June 15, 1935, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	*REFERENCES*	
	Proposers	*Seconders*
ALEXANDER, S. W., Mgr. Htg. Div., Jas. Morrison Brass Co., Toronto, Ont., Can.	A. H. Hills E. H. Gurney	E. T. Flanagan W. R. Blackhall
BAKER, C. T., Consulting Engr., Atlanta, Ga.	W. H. Carrier E. T. Lyle	C. L. Templin F. W. Clare
BLAKELEY, HUGH J., Htg. and Vtg. Engr., Office of Hollis French, New Haven, Conn.	L. A. Teasdale P. A. L. Foulds	F. A. Merrill R. H. Carpenter
CONRAD, ROY, Application Engr., Kelvinator Corp., Detroit, Mich.	A. P. Darlington H. E. Paetz	E. L. Hogan C. T. Morse
CORNWALL, C. C., Draftsman & Estimator, The Bahnson Co., Winston-Salem, N. C.	F. F. Bahnson Arvin Page	W. A. Perry *(Non-Member)* R. P. Reece *(A.S.M.E.)*
DICK, A. V., Sales Engr., Vandecar-Harmon Co., Schenectady, N. Y.	J. J. Devine *(Non-Member)* O. C. VanDecar *(Non-Member)*	L. A. Welch, Jr. E. A. Fessenden *(A.S.M.E.)*
FARBMAN, LEONARD X., Engr., Morris Farbman, New York, N. Y.	C. M. Humphreys T. F. Rockwell	H. W. Fiedler A. V. Hutchinson
GAULEY, E. R., Sales Engr., W. H. Cunningham & Hill, Ltd., Toronto, Ont., Can.	Thomas McDonald H. D. Henion	W. P. Boddington W. R. Blackhall

JENNINGS, S. A., Chief Draftsman, Trane Co. of Can., Ltd., Toronto, Ont., Can.	G. E. Cole J. W. O'Neill	Thomas McDonald W. P. Boddington
JIMENEZ, J. G., Director, Joaquin Gil Jimenez, Madrid, Spain.	R. T. Thornton E. E. Johnson	A. D. Alecha *(E.S.E.)* A. L. Mahiques *(A.S.R.E.)*
KAISER, FRED, Dist. Mgr., Minneapolis-Honeywell Reg. Co., Buffalo, N. Y.	M. C. Beman B. C. Candee	G. F. Erdle H. C. Day
KASTNER, G. C., JR., Sales Engr., Philips & Ibsen, Inc., New York, N. Y. *(Advancement).*	Elliott Harrington J. J. Donovan *(Non-Member)*	M. C. Giannini E. Jopol *(Non-Member)*
KYLE, W. J., Power Sales Engr., Byllesby Engrg. & Mgt. Corp., Chicago, Ill.	J. F. S. Collins, Jr. R. J. J. Tennant	D. L. McNulty *(A.S.M.E.)* G. W. Ousler *(E.S.W.P.)*
LAUTERBACH, HENRY, JR., Asst. Chief Engr., Carrier Engrg. Corp., Dallas, Texas.	I. I. Bock C. N. Witmer	G. H. Meffert O. W. Bynum
LEGLER, F. W., Mgr. City Office, The Waterman-Waterbury Co., Minneapolis, Minn. *(Advancement).*	F. B. Rowley H. M. Betts	F. G. Sedgwick *(Non-Member)* J. R. Hall
MADDUX, O. L., Chief Engr., United Gas & Fuel Co. of Hamilton, Ltd., Hamilton, Ont., Can. *(Advancement).*	E. H. Gurney W. R. Blackhall	Thomas McDonald M. W. Shears
MAXWELL, G. W., JR., Member, Kenealy & Maxwell Co., Harwich Port, Mass. *(Advancement).*	C. M. Humphreys T. F. Rockwell	G. B. Ober *(Non-Member)* R. A. Walls *(Non-Member)*
MCLAREN, F. S., JR., Air Cond. Engr., Frigidaire Corp., New Orleans, La.	H. W. Moore G. E. May	J. J. Wilmore *(Non-Member)* J. C. McKinnon *(Non-Member)*
MEARS, L. A., Air Cond.-Commercial Engr., General Elec. Co., Oakland, Calif.	F. H. Faust D. W. McLenegan	Elliott Harrington P. S. Lyon
PULLEN, R. R., Asst. Master Mech., Homestake Mining Co., Lead, S. D.	D. M. Forfar J. B. Wilson *(A.S.M.E.)*	W. G. Brennan *(A.S.M.E.)* Q. M. Crater *(W.S.E.)*
STENGEL, F. J., Secy., R. F. Stengel & Son, Irvington, N. J.	C. M. Humphreys T. F. Rockwell	P. Nicholls F. C. Houghten
TASKER, CYRIL, Research Fellow in Fuels, Ontario Research Foundation, Toronto, Ont., Can.	E. H. Gurney D. I. Paul	W. P. Boddington M. W. Shears
WEBB, E. C., Mgr. Engrg. Service, Iron Fireman Mfg. Co., Cleveland, Ohio.	C. F. Eveleth F. A. Kitchen	F. R. Dickenson E. J. Vermere
WHITNEY, C. W., Gen. Mgr., Trilling & Montague, Philadelphia, Pa.	R. A. Gemmill P. L. Pryibil	J. H. Hucker W. A. Bornemann

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BAUGHMAN, L. R., Supt. of Plbg. & Htg., Zion Inst. & Ind., Inc., Zion, Ill.

CONATY, BERNARD M., Sales Mgr., American District Steam Co., North Tonawanda, N. Y.

COWARD, C. W., Pres. & Gen. Mgr., Coward Engrg. Co., Camden, N. J.

ELLIS, G. P., Chief Engr., Board of Education, Pittsburgh, Pa.

FOX, ERNEST, Asst. to Engr., C. A. Dunham Co., Ltd., Toronto, Ont., Can.

MARSHALL, W. D., Mgr., Htg. Dept., Noland Co., Inc., Washington, D. C.

MOORE, H. C., Instructor in Mech. Engrg., Mass. Inst. of Tech., Cambridge, Mass.

PAGE, ARVIN, Asst. Chief Engr., The Bahnson Co., Winston-Salem, N. C.

STEVENSON, M. J., Regional Engr., Frigidaire Corp., Dayton, Ohio.

WOLF, PHILIP, Pres., City Contracting Co., New York, N. Y.

ASSOCIATES

EARLEY, THOMAS J., Sales Engr., Jennison Co., Fitchburg, Mass.

GORDON, W. D., Sales Engr., Tuttle & Bailey Co. of Can., Ltd., Fort Erie North, Ont., Can.

KARGES, ALBERT, Mgr., Jas. Stewart Mfg. Co., Ltd., Woodstock, Ont., Can.

PALMER, ROBERT T., Patent Lawyer, Boston, Mass.

JUNIORS

GILMORE, L. A., Vice-Pres., John Gilmore & Co., St. Louis, Mo. *(Advancement.)*

GRABENSTEDER, LOUIS, Power Sales Engr., Union Gas & Elec. Co., Cincinnati, O.

HANKINS, R. P., Engr., G. A. Peple, Jr., Richmond, Va.

MACHIN, D. W., Engr., Pittsburgh & Midway Coal Mining Co., Kansas City, Mo.

MAY, J. W., Instructor, University of Kentucky, Lexington, Ky.

MOHRFELD, H. H., Engr., Collingswood, N. J.

STUDENTS

BUTTARAVOLI, FRANK, Student, Pratt Inst., Brooklyn, N. Y.

CHROUCH, R. B., Grad. Student, Michigan State College, East Lansing, Mich.

CUNNINGHAM, J. S., Student, University of Ill., Urbana, Ill.

HAAS, R. B., Student, Michigan State College, East Lansing, Mich.

HOPP, H. K., Student, Pratt Inst., Brooklyn, N. Y.

LEVENTHAL, BERNARD, Student, Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.

MILLER, L. L., Student, University of Minn., Minneapolis, Minn.

How TO GET MORE FOR YOUR MONEY

when buying motors . . .

CHECK THE FRAME—This is important, because motor frame sizes are standardized. Thus the frame which has the necessary strength and rigidity with least bulk will allow more room for more copper and iron in stator and rotor. It also will provide larger openings for greater ventilation.

CHECK THE STATOR—Its laminations should be 28-ga. high silicon steel, heat treated, to insure high resistance, low retentivity and perfect insulation. There should be a maximum of iron in the stator section so that there is less idle current. The coil noses of the windings should be extremely short for the most effective use of copper.

CHECK THE INSULATION—It should be permanently pliable—should never dry out or crack. Not only should the insulation be waterproof but also highly resistant to acids, fumes and dirt.

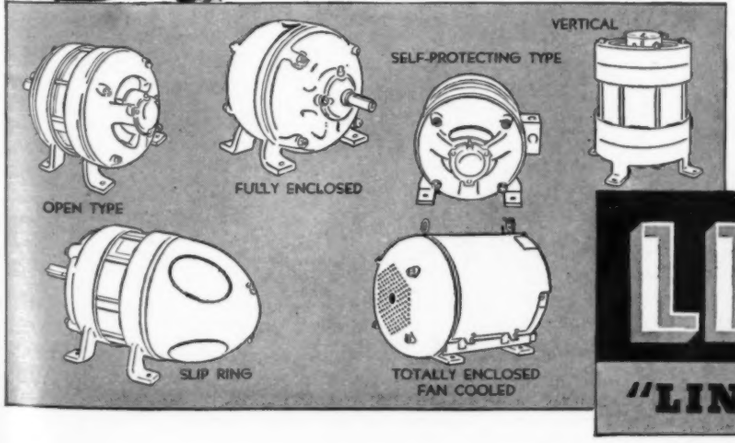
CHECK THE ROTOR—Be sure the laminations are not dependent on the windings to hold them together. The windings should be a single piece of metal to provide a perfect electrical circuit. The rotor shaft should be extra large, accurately machined and ground. Fans should have many steel vanes to whip large volumes of air through motor to insure cool operation.

CHECK THE PERFORMANCE—Motors which have the recommended features of construction will outperform all others. Will deliver extra horsepower without sacrifice of power factor or efficiency. Will give you more dependable service for your money. Will bear the name "Linc-Weld" on the nameplate. The Lincoln Electric Company, Cleveland, Ohio.

M-15

LAD "Congress, it seems, will do nothing about birth control."

POP "Yes, and it's too late for birth control to do any thing about Congress . . . so it gets back again to individual preference . . . just as I put it up to our plant electricians as to what motors I should buy—they all wanted *'Linc-Welds.'* Better they should have what they want than to say, 'You *must* take this and like it'."



LINCOLN

"LINC-WELD" MOTORS

INEXPENSIVE . . . . SIMPLE

yet indicates temperatures with scientific accuracy

Bristol's new Electric Thermometer is of the indicating design. Of delicate sensitivity, it is a precision device conforming to the highest requirements of accuracy. Standardization at proper intervals keeps accuracy permanently constant.

The measuring elements or resistance bulbs are interchangeable. If one is accidentally destroyed, it can quickly and inexpensively be replaced by another. Installed at any convenient central headquarters, this Electric Thermometer can be used to indicate the temperatures at any number of distant points.

Above: Sensitive and accurate over the entire range from 40° F to 300° F, Bristol's Electric Indicating Thermometer consists of (1) as many resistance bulbs as there are locations where temperatures are to be taken, (2) a multiple point rotary switch for connecting into instrument circuit any one of the several bulbs, (3) the indicating instrument with extra wide temperature scale, (4) a modified form of Wheatstone bridge having four resistance arms (two of which are equal, a third which is equal to the resistance of the bulb at the highest scale temperature, and a fourth arm which is equal to the resistance of the bulb at the lowest scale temperature), together with (5) a battery, (6) a standardizing rheostat, and (7) a double throw switch for substituting the bulb for the fourth bridge resistance arm.

THE BRISTOL COMPANY, WATERBURY, CONN.

Branch Offices in principal cities. Canada: The Bristol Company of Canada, Ltd., Toronto, Ontario. England: Bristol's Instrument Co., Limited, London, S. E. 14.

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PIONEERS IN PROCESS CONTROL SINCE 1889

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 92 . . . Add the new products and companies listed here to your Directory Section which you received in your January 1935 HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up-to-date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

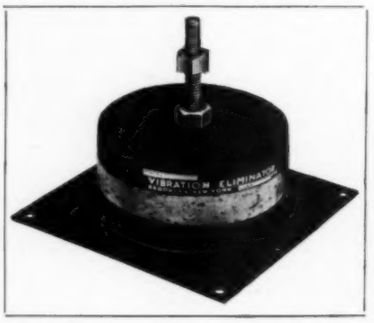
New Cell Type Air Filter

No. 318**—New "Spider Web" cell type air filter utilizes animal hair as filtering media, sterilized and deodorized and subjected to successive mechanical and chemical treatments. In making up each individual cell, central portion is built up of fibers having high resiliency to maintain media in its expanded condition, pressing outward and holding it against side of container to prevent packing and sagging. Outer portion is treated with fixative to maintain form of entire pad, and back or outlet side treated with adhesive oil. Fibers on face of filter are formed mechanically into corrugations and are not coated with adhesive, which treatment is designed to allow the dust to enter the cell rather than to pack up on the surface, said to insure large dust holding capacity.

Container is of spider web design, with free area increased slightly toward margins where resistance is higher to make possible more uniform flow of air over entire cell face.—Wilson & Co. (Hair Division), 4100 S. Ashland Ave., Chicago, Ill.

New Vibration Eliminator

No. 319**—New natural cork vibration eliminator for isolating machine vibration consists of base stamping and supporting housing to which the leg or base of the machine may be rigidly fastened. Machine is bolted to eliminator and eliminator bolted to floor.



Three sizes available: No. 22 for loadings between 65 and 100 lb each, base 3x3 in., height, 2 in.; No. 23 for loadings between 100 and 200 lb, base 4½ x 4½ in., height, 2 in.; and No. 24 for loadings between 175 and 375 lb, base 5½ x 5½ in., height, 2 in. —Vibration Eliminator Co., 41-26 37th St., Long Island City, N. Y.

Color Indexing for Valves

No. 320*—Color indexing now is applied to valves in the form of a new type of valve wheel molded of colored plastic materials, making it possible to designate distinctly valves for steam, water, air or other fluids and gases. Five standard colors: blue, red, black, green and gray, offered unmarked and with five standard service markings molded in relief. Wheels of special color or with special markings can be made. The maker states that they are strong, cool to the touch, easy to grasp, sanitary, permanent in color and pleasing in appearance.—Jenkins Bros., 80 White St., New York, N. Y.

How Fedders Gives You

COMPLETE

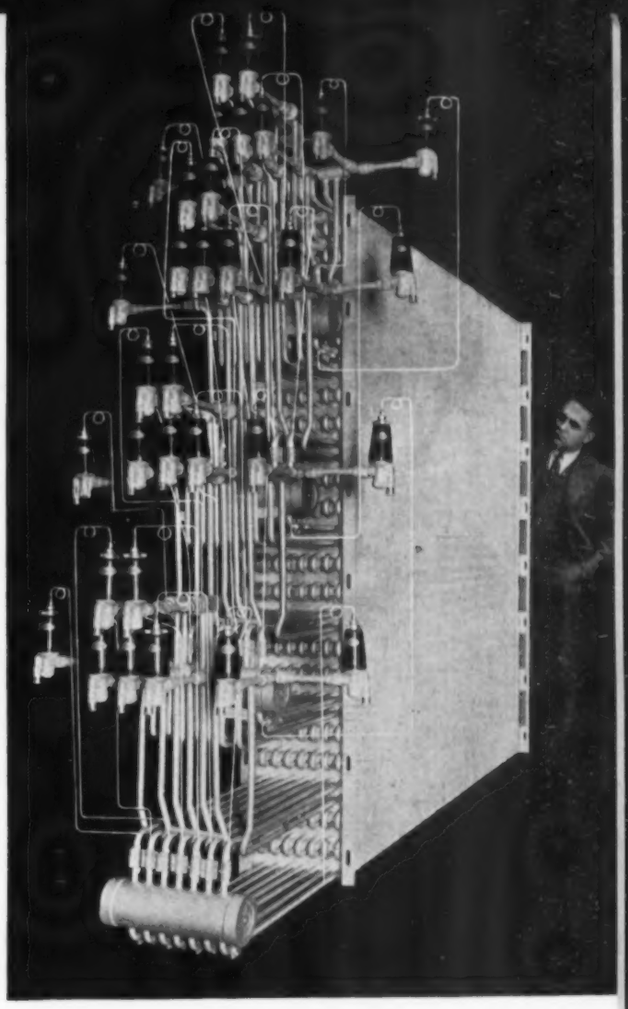
Air Conditioning

LOW SIDES

ON A

PACKAGE BASIS

Including Cooling and Dehumidifying



Pats. Pending
Photograph of a Complete Fedders Low Side including Cooling and Dehumidifying Coil and Fedders Valves.

Coils and Thermostatic Expansion Valves

U. S. Pats. 1,987,948, 1,974,631

Air conditioning requires refrigeration on a TONNAGE BASIS. The larger the job, the more exacting are the requirements for effective heat transfer surface and accurate refrigerant control.

Fedders coils are cataloged on a Package Basis in 75 models with capacities sufficient for use with condensing units from 1 to 100 horsepower.

With Fedders Model 33-HC High Capacity Thermostatic Expansion Valves, they make a complete low side. Separate inlet manifolds make it possible for each row of tubing to be fed and controlled with its own valve thus obtaining the greatest effectiveness out of the coil in accordance with the varying temperature differentials as the air progresses through the coil.

Flexibility and accuracy of refrigerant control assure proper synchronization between the "low side" and the condensing unit with consequent efficiency and economy.

The cutaway view at the left shows the large, unrestricted passageways of the Fedders High Capacity Thermostatic Expansion Valve. Its sensitive, easy adjustment is enabling air conditioning engineers to obtain and maintain a well balanced condition throughout the system.

Advanced engineering . . . Complete low sides . . . 75 models cataloged on a package basis; all-copper and brass construction—those are just a few reasons why air conditioning engineers are specifying Fedders.

This book puts COILS for AIR CONDITIONING on a Package Basis.

Write for your copy of Fedders Data Book on Cooling and Dehumidifying Coils. It will save you hours of time in figuring. The coupon is for your convenience.

H P.6

Fedders Manufacturing Co.
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Please send me your Data Book 91 covering air Conditioning Low Sides on a package basis—to personal attention of

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Concern .....

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923 E. 3rd St., Los Angeles

Uncontrolled —a Menace

Ewing Galloway Photo

Controlled —a Boon

Water uncontrolled may be a devastating flood. Controlled and regulated, it makes the desert blossom as the rose.

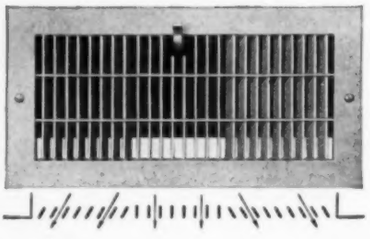
Air uncontrolled is a menace to health and comfort. Accurately controlled, as is possible with Independent "Fabrikated" Adjustable Directed Air Flow Registers and Grilles, it enables the heating and ventilating engineer to achieve results unattainable a year ago.

Grille bars, either horizontal or vertical, can be adjusted before or after installing to any angle up or down, right or left, to as much as 45 degrees.

INDEPENDENT REGISTER & MFG. CO.
3757 E. 93rd St. Cleveland, Ohio

INDEPENDENT
"Fabrikated"
(Reg. U. S. Pat. Off.)
ADJUSTABLE Directed Air Flow REGISTERS AND GRILLES

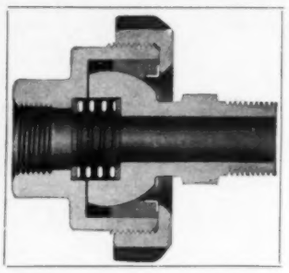
Send for catalog and data book



Forged Iron Ring Gasket

No. 321—New line of "Gruv-Seal" drop forged iron ring gaskets designed especially for high pressure and high temperature piping wherever bolted joints are effected with grooved flanges, and where ready dis-assembly is a requirement. They are manufactured in sizes from 2½ to 14¾ in. of both Armco Ingot Iron for high temperatures and pressures and of special acid-resisting metals to specifications.—The Steel Improvement & Forge Co., 960 Addison Rd., Cleveland, O.

Joint Connects Piping Between Moving Parts



No. 322 — Improved swivel joint is for use on platen presses, tire and tube molds, and similar machinery, to connect piping between moving parts. Incorporated is a metal washer or bearing at each end of the spring to eliminate the spring wear on the two major parts of the joint, the ball and casing, prolonging joint life and reducing possibility of spring breakage.—Barco Mfg. Co., Chicago, Ill.

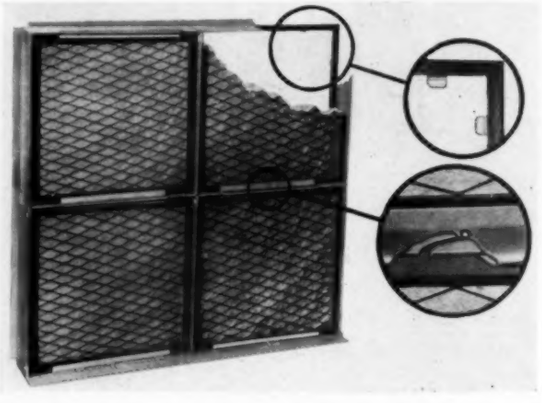
Gate Valve for Convector Radiators

No. 323—New gate valve for convector radiators is designed to offer a compact straightway valve that can be used conveniently within the restricted dimensions found in enclosures; it has a female union on one end to facilitate installation when a bottom connection is used on radiators of this type. Male thread on other end screws directly into convector before the latter is set in position. Union connection is then screwed down over the stub after the radiator has been placed.

Valve is of the packed type finished in rough brass, has long stem to make the handle, of special non-heating composition, easily accessible in the opening beneath enclosures.—American Radiator Co., 40 W. 40th St., New York, N. Y.

New Air Filter Frame

No. 324—New air filter frame increases filter efficiency by employing felt strip between filter and frame against which filter is tightly held by simple wedge lock, providing positive seal to prevent leakage of dirt-laden air at any point. Illustration shows closeup of square felt strip inserted when frame is constructed and



held in place by bending metal tabs over frame flanges. Also shown is detail of wedge lock applied on intake side of frame to force filter firmly against the felt "gasket." Device is self-adjusting to variations in thickness of filters in bank.—Owens-Illinois Glass Co., Toledo, O.

AEROFIN

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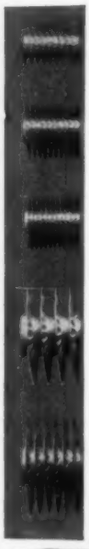
HEATING AND COOLING SURFACE

•

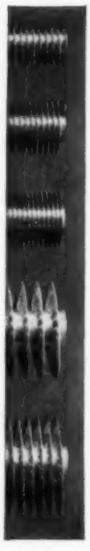
SPECIFY AEROFIN FOR HIGHEST EFFICIENCY

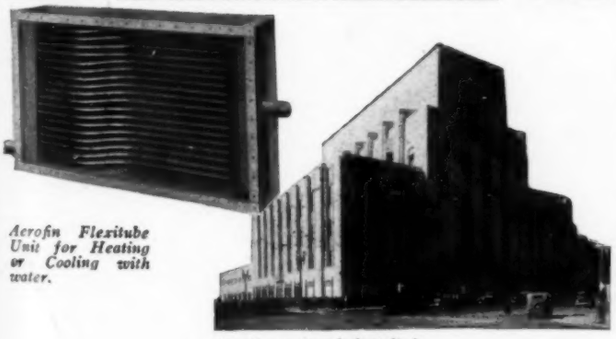


Aerofin Standardized Light Weight Fan System heat exchange surface is the first choice of architects, engineers and building owners for Heating or Cooling because of its proved superiority. Progressive heating and cooling contractors install it because it gives complete satisfaction.

Aerofin is years in advance of ordinary heating and cooling surface because of its exclusive features. It is available in aluminum, copper or other special metals. Whatever you have wished for in a fan system surface you will find in Aerofin.

The home office in Newark or any of our branch offices will gladly send complete descriptive literature or render prompt, personal and efficient technical cooperation. Simply write to the address below.





Aerofin Flexitube Unit for Heating or Cooling with water.

Aerofin surface is installed in the Los Angeles Times Building. Gordon B. Kaufmann, Architect. P. J. Walker Company, Building Contractors. Carrier Engineering Corporation, Air Conditioning Contractors.

AEROFIN CORPORATION
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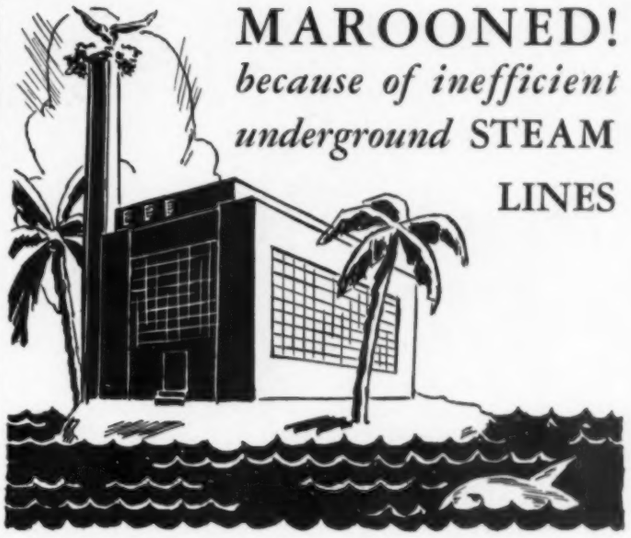
AEROFIN is sold only by Manufacturers of Nationally Advertised Fan System Apparatus. List upon Request



MAROONED! *because of inefficient underground* STEAM LINES

THIS power plant is the last word in modern design and equipment, yet its potential efficiency is marooned—lost because the savings it makes possible are dissipated due to inefficient underground steam lines. Cheap steam transported in lines not properly protected and insulated is costly steam when it arrives at destination.

Hundreds of power plants the country over are being penalized because of an "out of sight, out of mind" attitude towards this problem. Let us show you how RIC-WIL Conduit Systems, by providing permanent protection and insulation for underground steam lines, will insure full realization of "modern power plant economies."

RIC-WIL offers a variety of types, materials and insulation to meet every underground piping requirement. There is a dependable RIC-WIL representative in your vicinity who is alert to your problems. Call on him at any time—or write us direct.

The RIC-WIL Co., 1562 Union Trust Bldg., Cleveland, Ohio
New York San Francisco Chicago
Agents in Principal Cities

RIC-WIL DRY-PAC is pure asbestos insulation, which has certified conductivity of only .36 B.T.U. for low pressure.

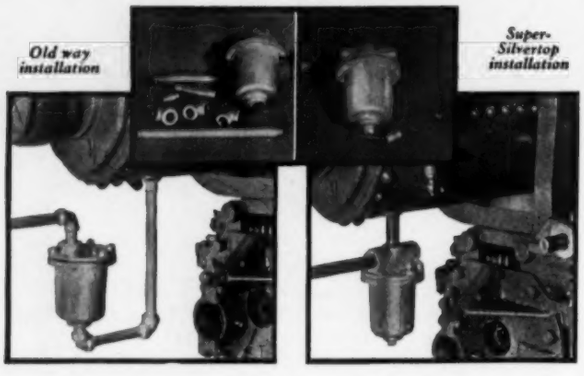
REGISTERED IN U. S. PATENT OFFICE

RIC-WIL

CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

Take Advantage of these

SUPER-SILVERTOP SAVINGS



Super-Silvertop can be inspected without disturbing pipe connections

● You can actually *see* Anderson Super-Silvertop Steam Trap savings. The illustration above compares an old style trap and Super-Silvertop on identical installations. Super-Silvertop saves three elbows and three nipples. You also save 40 to 60 minutes' installation time per trap. Super-Silvertop averages 76% greater capacity than other traps of equal size and price—a saving in first cost. When it comes to trap inspection (good engineering practice) you again save because this trap can be inspected without removing from the line.

Specify Super-Silvertop on your next installation. Use it either as an elbow as shown above or straight-in-line. Super-Silvertop is a complete trap—no extras to buy. Super-Silvertop gives you the greatest dollar value of any steam trap. Send for complete details and prices.

THE V. D. ANDERSON COMPANY
1949 WEST 96th STREET • CLEVELAND, OHIO

THE V. D. ANDERSON COMPANY, *1949 West 96th St., Cleveland, O.*

Gentlemen: Please send me complete information on the Anderson Super-Silvertop Steam Trap.

*Name of Firm*_____

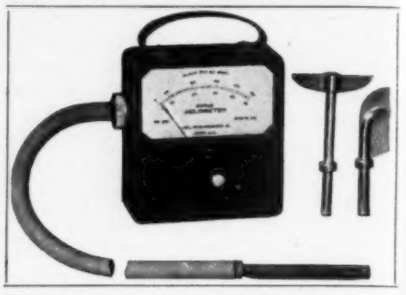
*Attention of*_____

*Address*_____

*City*_____ *State*_____

Direct Reading Air Velocity Meter

No. 325**—"Boyle Velometer" is a direct reading air velocity meter reading air motion in feet per minute. Housed in black bakelite case 5¼ x 5¾ x 2⅜ in., it weighs approximately 2 lb. The air enters through a port or a jet and tube (depending on the style used) and leaves through a port on the right side of the meter, passing through the meter to actuate a movement comprising a vane, control springs, pointer, and magnetic damping system. Pointer locking button retains the reading or locks pointer when instrument is not in use.



Instrument is furnished in two types each with a double range scale, the shutter type, for taking quick commercially accurate readings such as in heating, ventilating and air conditioning work, and the tube type (illustrated) which in addition to being useful for heating and air conditioning service is used for determining air movements in dryers, kilns, or like equipment. Special scales and attachments can be built for unusual applications such as high velocities and high temperatures.

Standard scale range is 0-300 and 0-3000 fpm although other ranges are also offered. Low scale on either type provides accurate readings as low as 20 fpm, the maker states.—Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago, Ill.

Self-Contained Air Conditioning Units

No. 326—The two new air conditioning units illustrated are self-contained and equipped with thermostatic controls and provisions for outside ventilation with air filters. The unit at the left

has approximately ⅜ of a ton refrigeration capacity and the other approximately ¾ of a ton. Both are designed for individual installations, particularly in homes and offices, although they are suitable for other applications such as hotel rooms, hospitals, and retail shops. Smaller unit retails for $420, f.o.b. Dayton, and the larger $579.—Frigidaire Corp., Dayton, O.

Conventions and Expositions

Coal Utilization Short Course: June 11-13, College of Engineering, University of Illinois, Urbana, Ill. Under auspices of the departments of mining and metallurgical, and mechanical engineering.

National District Heating Association: Annual convention, June 11-14, Bellevue-Stratford Hotel, Philadelphia, Pa.

WHEN INSIDE SURFACES

MUST BE CLEAN

Especially is this of vital importance in the smaller pipe sizes where the percentage of capacity may be materially decreased and small valves and instruments may be rendered useless by a small amount of foreign matter.

Fretz-Moon Pipe is as clean inside as outside—even in the smallest galvanized size. In its original form as skelp, at the beginning of the "continuous process," it is as clean as flat-rolled steel can be had. Throughout every phase of the "continuous process," this cleanliness is protected. Never once does the skelp come in contact with the furnace bottom where it may be contaminated by foreign matter. And when galvanized, the pipe is blown clean inside by superheated steam.

If you're looking for clean pipe, consider Fretz-Moon. Ask us to send you a sample taken from stock.

FRETZ-MOON TUBE CO., INC.
BUTLER • PENNA.

FRETZ-MOON
PIPE
BLACK AND GALVANIZED

Cut the Plug or Seat in Several Places..... Yet it Can't Leak !!

The plug and seat ring in Fairbanks 0501-P Plug Type Regrinding Valves have *three* times the sealing surfaces of ordinary valves. So if these parts should be cut in several places by wire drawing or erosion, there would still be sufficient undamaged surface in the long seating area to prevent leakage.

Moreover, the force of the stream cannot be concentrated on any part of the plug or seat to cause erosion or wire drawing.

But should the seating surfaces become scored or cut, they can be readily reground or renewed.

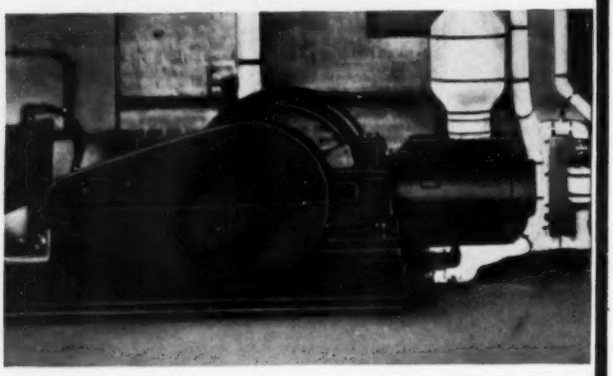
The result is longer life, lower maintenance cost and less work and worry for the engineer.

Other outstanding features of these Fairbanks Bronze Globe and Angle Valves are explained in our Booklet 0501-P. Write for your copy.

THE FAIRBANKS COMPANY
Manufacturers of Valves, Hand Trucks and Wheelbarrows
396 Lafayette St., New York, N. Y.
Boston, Pittsburgh—Distributors in Principal Cities

FAIRBANKS
PLUG TYPE VALVES

For
STEAM PRESSURE and TEMPERATURE BEYOND EXISTING BOILER CAPACITY...
use a
WORTHINGTON STEAM BOOSTER COMPRESSOR



NO costly boiler plant changes necessary. A Worthington Steam Booster will produce a higher steam pressure and temperature level . . . and save money. Built to meet individual requirements.

- Steam, motor-belted, or direct-motor drive
- Worthington Feather Valves for highest efficiency
- Double tapered roller main bearings
- Automatic bearing lubrication
- Force-feed cylinder lubrication

Worthington engineers will be glad to study your exact conditions

● *Send for Bulletin*

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WORTHINGTON PUMP AND MACHINERY CORPORATION
General Offices: HARRISON, NEW JERSEY
Branch Offices in Principal Cities throughout the World

WORTHINGTON

American Society of Heating and Ventilating Engineers: Semi-annual meeting, June 17-19, Royal York Hotel, Toronto, Ont. A. V. Hutchinson, Secretary, 51 Madison Ave., New York, N. Y.

American Society of Mechanical Engineers: Semi-annual meeting, June 19-21, Cincinnati, Ohio. Secretary, C. E. Davies, 29 W. 39th St., New York City.

American Society for Testing Materials: Annual meeting, June 24-28, Book-Cadillac Hotel, Detroit, Mich. Exhibit of testing and related equipment to be held concurrently. Assistant Secretary, R. E. Hess, 260 S. Broad St., Philadelphia, Pa.

Great Lakes Power & Mechanical Exposition: June 24-28, on Steamer "Seeandbee," starting from Cleveland. Ernest H. Smith, Managing Director, 3910 Carnegie Ave., Cleveland, Ohio.

Midwest Power Show: October 14-18, Chicago, Ill. G. E. Pfisterer, Managing Director, 1 N. LaSalle St., Chicago, Ill.

American Gas Association: Annual convention, October 14-18, Atlantic City, N. J.

International Heating & Ventilating Exposition: January 27-31, International Amphitheater, Chicago, Ill. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

Booklets, Reports and Papers

Steam Requirements of Office Buildings

"Steam and Electrical Requirements of Office Buildings," a report of the sales committee, Edison Electric Institute, 420 Lexington Ave., New York, N. Y. 14 pp., 8½x11 in. For sale by the Institute; 30c to members and their employees, 75c to non-members in U. S., 85c foreign.

Purpose of this report is to provide a group of basic factors that may be used to determine approximate steam and electrical requirements of office buildings, which are divided into three classes depending upon type of occupancy. Tables of unit consumption derived from tests and operating data in a large number of buildings in several cities are given. Included are curves developed from the data showing relation between outdoor temperature and building heating; between outdoor temperature and exhaust steam wasted by an isolated power plant; and between lighting consumption and hours of sunshine per month. An example of the method followed by one operating company in developing the comparative heat, light, and power costs of a building with an isolated power plant and the same building with purchased electric service supplements the curves and tables.

Following a preliminary discussion, characteristics of electric loads (lighting, elevators, house water pumps, ventilation and air conditioning, miscellaneous and total) are covered, followed by discussion of steam load characteristics for building heating, hot water heating, and other uses. An appendix describes the degree hour chart and its development, and the average hourly temperature range curve.

Book Reviews

Mechanical Engineering Laboratory Text

"Mechanical Engineering Practice," by Charles F. Shoop, Professor of Steam Engineering, University of Minnesota, and George L. Tuve, Associate Professor of Mechanical Engineering, Case School of Applied Science. 2nd edition, 1934. McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. 477 + xii pp., 6x9 in., clothbound. $4.00,

Omission of the word "Laboratory" from the title of this edition is in keeping with the changes throughout the book, the aim having been to produce a reference text which will also serve as a

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The first book to treat of air conditioning in its industrial applications

"INDUSTRIAL AIR CONDITIONING PRACTICE"

324 Pages—Size 5½"x8"
Cloth Bound—$2.50

Here is a new book offering engineers and contractors the most valuable collection of information yet gathered together on the subject of industrial air conditioning.

This practical volume clearly and exhaustively explains the need for and value of air conditioning in the textile, ceramic, leather, food, chemical, brewing, baking, paperboard, process, flour, printing, and many other industries. It shows how air conditioning has improved products in these plants, how it has speeded production, saved money, and in general become an indispensable part of efficient manufacturing processes.

Compiled principally from material published originally in HEATING, PIPING and AIR CONDITIONING, this volume embodies the accumulated practical knowledge of 25 outstanding air conditioning specialists. Every phase of the whole subject of industrial air conditioning—from fundamentals and equipment, through the design, installation, operation, and maintenance of the different types of systems, and the problems relating to each—is explained thoroughly and plainly by these men, from the standpoint of their successful experience.

There is a world of practical, authoritative information in this book for everyone interested in industrial air conditioning. Whether you are an operating, consulting, designing, or contracting engineer, you may turn to this book with assurance for reliable facts on almost any industrial air conditioning question you want answered or any problem you may have to solve.

Send for a copy today. Remit $2.50 to the address below, and a copy will be mailed to you promptly. You will be privileged to return the book within 10 days for a refund if for any reason you do not care to keep it.

KEENEY PUBLISHING COMPANY
6 North Michigan Avenue
Chicago, Illinois

Is HEAVY PIPE a "HABIT"?

Although the use of Taylor Spiral Pipe has increased tremendously in recent years it has not increased nearly as rapidly as it would have if it were not for the tendency of industry to think too often in terms of *heavy* pipe!

You may want a *strong* pipe. You may want a durable pipe. But surely you do not want an ounce more weight than is necessary.

Taylor Spiral Pipe is the strongest pipe of its weight. It has greater bursting strength, greater collapsing strength, greater longitudinal stiffness—gauge for gauge and size for size—than any other type of pipe.

Durability in excess of most requirements is made possible by modern coating methods perfected by Taylor Forge. A wide range of joints and fittings conform to every conceivable condition, and the increased use of welding has still further broadened its utility.

Before you install heavy pipe, check the requirements against the capabilities, cost, and adaptability of modern spiral pipe. The checkup may convince you that heavy pipe *is* a "habit"!

Taylor Forge & Pipe Works
General Offices & Works
Chicago, Ill., P. O. Box 485
New York Office, 50 Church St.

TAYLOR SPIRAL PIPE

LIGHT WALL PIPE FOR ALL PURPOSES

A COMPLETE LINE OF

CONTROL VALVES
for Air Conditioning

—ONE SOURCE OF SUPPLY
—UNIFORMITY OF PERFORMANCE . . .

There is an Alco Valve for every specific requirement for NH3, CH3CL and F12 with capacities ranging from fractional tonnage to 60 tons.

Today, when air conditioning applications are so wide and varied, it is wise to standardize on an accurate, dependable line of controls. Uniformity of performance between the various types and capacities of valves is an important factor in the efficiency of any system.

There are nine Alco Valves for use in air conditioning systems — each especially designed to do a particular job. Alco Thermo Valves have the new atomic hydrogen welded Power Assembly and are guaranteed to maintain their accuracy and sensitivity for long periods of time under severe conditions.

Let the Alco staff of engineers help you with your designing, installation and operating problems. Helpful bulletins sent free on request.

ALCO VALVE COMPANY
2622 Big Bend Blvd., St. Louis, Mo.

Where Warmer Temperature is Controlled

· ALCO VALVES

manual of laboratory procedure. Content has been materially increased, including the addition of sixteen experimental projects mainly in heating, air conditioning, and internal combustion engines. Among the chapters which have undergone major revisions are those on heat transfer and measurement of fluid flow.

Following general laboratory instructions and an outline of report writing, Chapter 2 is devoted to methods and instruments for mechanical measurements. Chapters 3 and 4 relate to laboratory exercises, and lubrication, respectively. Chapter 5 on the transfer of heat takes up theory, and the solution of engineering problems, including heat losses from bare and covered pipes, test of a steam radiator, of a unit heater, and of a steam heating boiler.

The properties of gases and vapors is the subject of Chapter 6; a great deal of information on air conditioning is included in this chapter, with a discussion and instructions for testing the performance of an air conditioning unit. Chapter 7 is devoted to the measurement of fluid flow (including calibration of an anemometer). Following are chapters on pumps and compressors, steam power generating units and auxiliaries, refrigeration, and internal combustion engines. An appendix is devoted to reference tables and charts, and supplementary experiments.

This is a convenient handbook on experimental practice and a reference volume. Pertinent material in about two thousand pages of recent test codes and other practice recommendations has been included or indicated by specific references.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 92

No. 443. AIR COMPRESSORS: Worthington Pump and Machinery Corp., Harrison, N. J. Six page folder describing in detail the construction of vertical angle air compressors (two stage), dimensions, sizes and ratings.

No. 444. AIR CONDITIONERS: Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. Eight page bulletin describing "Ortho-Clime" air conditioners for offices, stores, restaurants, shops, homes, etc., in wall, ceiling, or floor type models; compressors; and blast coils for duct installation. Also, loose-leaf booklet of specification details and capacities for the units and information on selection of blast coils for comfort cooling.

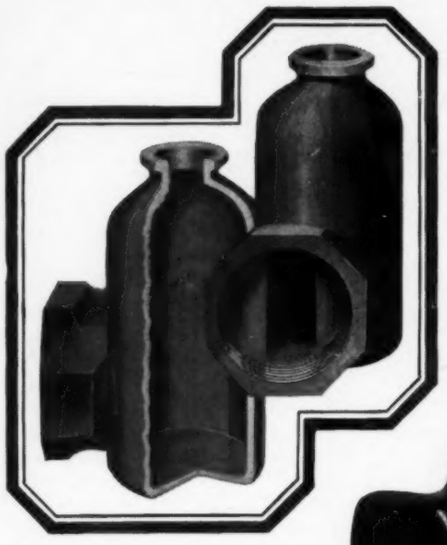
No. 445. AIR CONDITIONERS: York Ice Machinery Corp., York, Pa. Eight page booklet describing portable air conditioners, their applications and operation.

No. 446. AIR CONDITIONING: The Bryant Heater Co., Cleveland, O. 16 page booklet "The Trend in Summer Air Conditioning" devoted to dehumidification by adsorption and its importance in air conditioning for industry and for comfort, illustrating numerous buildings in the United States and South America equipped with air conditioning apparatus of this type. Operation of this company's silica gel dehumidifier is described.

No. 447. AIR CONDITIONING: Minneapolis-Honeywell Regulator Co., 2701 Fourth Ave., S., Minneapolis, Minn. 32 page booklet "This Thing Called Air Conditioning" presenting an interesting review of factors involved in air conditioning and the importance of automatic control to the proper functioning of an air conditioning system in winter and summer. Several paragraphs are devoted to the importance of building construction, types of air conditioning systems, and the air conditioning of existing buildings and of new buildings. The field for air conditioning in large buildings and in industry is a brief and readable review.

No. 448. AIR CONDITIONING CONTROL: Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa. 24 page booklet "Efficient Regulation of an Air Conditioning System" describing in detail the application of three-lead, null-type electrical-resistance thermometers for control of central station air conditioning systems. Principle is thoroughly explained, location

For All Air Conditioning Requirements



MARLEY patented spray nozzles provide a finer, more uniform spray and operate efficiently under low pressures.

That is one of the important reasons why more Marley nozzles now are being sold than any other kind.

Marley nozzles are made in all sizes for all purposes. Write for Bulletin No. 59.

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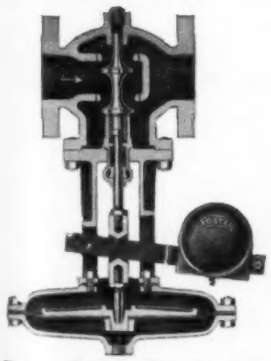
Above:—Marley standard, patented spray nozzle for water cooling systems —internal and external views.

Right:—Marley ice melting nozzle for use where ice is the refrigerating medium.

Marley small spray nozzle for air washing, brine spraying and other similar uses.

RUGGED PRECISE DEPENDABLE

Automatic Valves
for Correct Pressure Regulation



Foster Type 34B2 Pressure Regulator for general service. Recommended for initial pressures up to 250 pounds and for reduced pressures 0 to 50 pounds. Single-seated type for dead-end service. Standard sizes ½" to 12". Types 34A1 and A2 for delivery pressures up to 150 pounds.

Foster's line of Pressure Regulators for Steam, Liquids and Gases covers every class of service in the heating, ventilating and air-conditioning field. They have back of them 56 years experience in design and application.

Write to us about your requirements. If our standard valves are not the most suitable, we are in a position to design and make special valves.

Designers and Manufacturers of Automatic Valves since 1879.

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OUR FACILITIES enable us to handle your requirements whether you need one coil or one thousand coils; one square foot of surface or one thousand square feet.
You can order a coil with the PROPER DIMENSIONS and SURFACE and get it without delay at low cost.

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AIR CONDITIONING UNITS and COMMERCIAL REFRIGERATION

1/6 to 15 H. P.—Air and Water Cooled

The completeness of the Curtis line puts Curtis distributors in an enviable position especially in view of the extraordinary popularity of Air Conditioning.

Some desirable territories are still open for reliable distributors.

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Proven Design
Financial Stability

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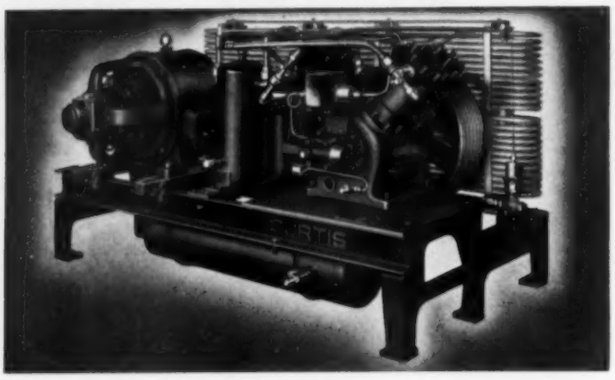


SUMMER-WINTER THERMOSTATS

A single instrument instead of two for the automatic control of cooling equipment in summer and heating equipment in winter. The snap-acting, spring blade contacts insure **freedom from chatter and vibration. Total differential of only 1° F.** Equally suited for low or line voltage. Beautiful in design. Satin Silver or Bronze finish in anodic Alumilite, and therefore unaffected by acid or alkaline corrosion, scratches, etc.

TYPE T/5W—Used to give reversible cycling on 2-wire control circuits.
LIST PRICE $18.50

TYPE T/66—Used to give reversible cycling on 3-wire control circuits.
LIST PRICE $18.75

TYPE T/45—Used to operate TWO SEPARATE LOADS.
LIST PRICE $18.75

Apply for details of our complete line of instruments for control, indication, and recording of air conditions for all purposes. Attractive Bulletin on request.

JULIEN P. FRIEZ & SONS, INC.
(Subsidiary of Bendix Aviation Corporation)
Baltimore, Maryland

of the units described and illustrated and choice of instruments discussed. The equipment is illustrated and described, and mounting dimensions are given.

No. 449. AIR CONDITIONING CONTROLS: Julien P. Friez & Sons, Inc., Baltimore and Central Aves., Baltimore, Md. Four page bulletin featuring humidistats and humidity and temperature indicators, including list prices. Also, four page bulletin of recorders for humidity, temperature and operation describing construction and applications in detail.

No. 450. COILS: Fedders Mfg. Co., 57 Tonawanda St., Buffalo, N. Y. Issue of "Fedders News" including article on figuring cooling and dehumidifying coils for air and refrigerant conditions other than standard.

No. 451. COOLERS: The Trane Co., La Crosse, Wis. Four page bulletin describing product coolers for forced circulation of refrigerated air in meat, vegetable, dairy, malt and similar storage rooms. Specifications, ratings, and dimensions are given.

No. 452. DUST RESPIRATOR: Mine Safety Appliance Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa. Leaflet describing new dust respirator.

No. 453. ELECTRIC HEATING: Hynes Electric Heating Co., 240 Cherry St., Philadelphia, Pa. 12 page booklet describing electric heating equipment for rooms, buildings, power plants, hydro stations, pump houses, substations, dam gates, penstocks, and water tanks with automatic control for economy. Among the equipment described is room heaters, industrial heaters, pressure blower heaters, fan systems with air ducts, dewpoint control. Data for computing heat loss in watts is included.

No. 454. FANS: The Trane Co., La Crosse, Wis. 24 page booklet devoted to forward curved multi-blade fans for heating, ventilating, drying and air conditioning. Construction details are described and illustrated, application recommendations given, roughing-in dimensions tabulated and duct construction illustrated. Complete capacity tables are included, and characteristic curves and tables of duct friction are shown.

No. 455. GRILLES AND REGISTERS: Tuttle & Bailey, Inc., New Britain, Conn. 48 page catalog of grilles and registers for air conditioning, including registers, grilles, volume control dampers, adjustable grilles to provide for air deflections, and duct turns for use in ducts to turn high velocity air around right angle elbows. Complete information is given about each unit, including capacity tables, installation details, construction features, etc., and several pages are devoted to technical data on air paths, air drop with various temperature differentials, etc.

No. 456. MOTOR CONTROL: Monitor Controller Co., Baltimore, Md. Leather bound loose-leaf booklet on automatic electric motor control including direct current magnetic contactors, current limit starters, time element starters and controllers, non-reversing magnetic controllers, reversing magnetic controllers; alternating current magnetic contactors, across-the-line starters, automatic starters, resistor type, reversing across-the-line starters, reversing automatic starters, resistor type, push-button stations, lever and button stations, lever type stations, drum type stations, limit switches, pressure and vacuum regulators, float switches, high and low alarm switch, foot switches, field rheostats. Ratings, features, and descriptions are given together with list prices.

No. 457. MOTORS: Allis-Chalmers Mfg. Co., Milwaukee, Wis. Four page bulletin describing direct current motors and generators for belted and direct connected applications of several types—enclosed, semi-enclosed, enclosed pipe ventilated, vertical.

No. 458. MOTORS: Century Electric Co., 1806 Pine St., St. Louis, Mo. Eight page bulletin on polyphase motors, 1/6 to 600 hp, designed for the requirements of air conditioning installations, refrigeration, blowers, fans, pumps, etc. Construction features are carefully described and illustrated.

No. 459. MOTORS AND VENTILATING EQUIPMENT: Diehl Mfg. Co., Elizabethport, N. J. 18 page simplified price list and catalog of electric motors, generators and ventilating equipment.

No. 460. PNEUMATIC TOOLS: Independent Pneumatic

G&O FINNED TUBING

Quality Service

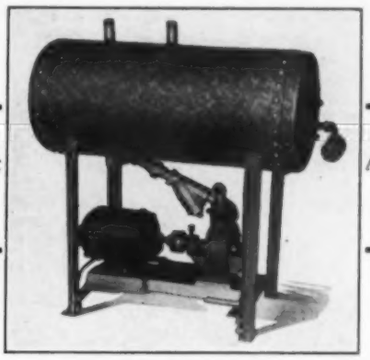
We are splendidly equipped to supply high efficiency finned tubing in a wide range of sizes for all heat transfer purposes.

CORRESPONDENCE INVITED

THE G&O MANUFACTURING CO.
142 Winchester Avenue - New Haven, Conn.
Established 1915
Manufacturers of "G & O" Automotive Radiators

Be sure of a constant water level in high or low pressure Boilers

M-K-O Automatic Boiler Feed



M-K-O Automatic Boiler Feed

All guess work is eliminated when the M-K-O Boiler Feed is installed. This unit automatically pumps feed water against high boiler pressure, returns condensate to the boiler and supplies make-up water as needed.
The M-K-O operates electrically, and uses none of the valuable steam. It is designed for use with gas or oil, stoker or hand fired boilers.
Send for full description and prices.

MEARS-KANE-OFELDT INC.

Executive Offices and Factory
1903-1915 EAST HAGERT ST., PHILADELPHIA
Branch Offices or Distributors in Principal Cities
Also makers of Kane & Ofeldt Gas Steam Boilers

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now offers the **MOST COMPLETE LINE** *of* **STEAM HEATING SPECIALTIES**

VALVES
TRAPS
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FOR EVERY TYPE OF STEAM HEATING SYSTEM

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Hoffman Specialty Co., Inc., Waterbury, Conn.

"Sure, you can get by with cheap pipe here, for a while. But if you want to save some REAL money, better let me put in Reading **Genuine Puddled Wrought Iron** Pipe. Then forget about repairs or replacements."

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SCIENCE AND INVENTION HAVE NEVER FOUND A SATISFACTORY SUBSTITUTE FOR GENUINE PUDDLED WROUGHT IRON

SILENT ** as the Sphinx

The heart of any air conditioning unit is the motor. The life and quality of the motor determine the life and quality of your product. Holtzer-Cabot motors are used by the leading air conditioning equipment manufacturers because of their consistent reliability.

1 **SILENT OPERATION**—Steel spring mounting definitely and permanently eliminates objectionable motor noise.
2 **BEARINGS**—Oversize bearings and extra large oil reservoirs provide long life with minimum of attention.
3 **ADJUSTABLE SPEEDS**—Provide for the proper regulation of air movement—so vital to the success of the modern air conditioning unit.

Our engineers will gladly confer with you. Their experience can be helpful—write Dept. 20 for descriptive bulletin.

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125 Amory St., Boston, Mass.
MOTOR SPECIALISTS FOR 50 YEARS

DART UNIONS
Non-Corrosive

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[*Continued from page 290, front section*]

Says Wm. V. Hoier[4]—The public has the right to expect a standard of minimum requirements as applied to air conditioning. Those who collectively represent this industry must weld themselves into a unit that will unselfishly subscribe to and furnish such information in concrete form so that all legitimate members of the trade will whole-heartedly combine to give it their unqualified endorsement.

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[5]President, L. H. Prentice Co., Heating and Ventilating Engineers and Contractors. Member of the committee which developed the standards.

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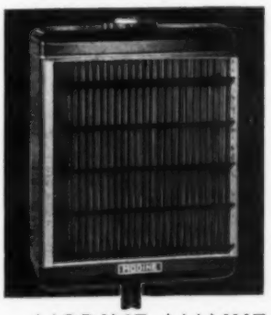

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